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MAY-1-I-03



HUMAN ANATOMY AND PHYSIOLOGY

M.A. Yogashastra



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Hon'ble Vice Chancellor's Message

Open and Distance Learning Centre of Kavikulaguru Kalidas Sanskrit University is publishing Study material for Post Graduate Degree program in Sanskrit and Yogashastra.

Scholars from different fields are fascinated by Sanskrit Studies, but due to work interruption or any other reasons, they cannot study Sanskrit regularly. For all such curiosities, M.A in Sanskrit and Yogashastra has been introduced through ODL Center by KKSU. The new commencement of these postgraduate program is taking place from 2020-21. The scope of university education will be expanded through open and distance centers. In today's changed scenario of teaching and learning, it will be easier and convenient for everyone to learn their favorite subject anytime anywhere.

The study material of these courses will first be available in the local language, namely Marathi and in the national, international and Sanskrit languages. I am sure that the Sanskrit language will reach people from different walks of life through curiosities in different fields but it will also affect those areas.

I congratulate, the editorial board, the author and the director of the Open and Distance learning Centre, Dr. Hrishikesh Dalai who worked tirelessly for the publication of this study material.

Prof. ShrinivasaVarakhedi
Vice-Chancellor

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UNIT - 1

UNIT-1

Chapter - 1 The cell and its function

1.1 Preface

All the living things are composed of cells. A single cell is the smallest unit that has all the characteristics of life.

Definition : Cell is defined as the structural and functional unit of the living body.

Each of the 100 trillion or more cells in a human being is a living structure that can survive indefinitely and in most instances, can even reproduce itself provided its surrounding fluid contain appropriate nutrients.

1.2 Objectives

- 1) To study basic details of cell and tissue.
- 2) To study general characteristics of cell.
- 3) To study basic structure of cell.
- 4) To study functions of cell.
- 5) To study basics about the types of tissues and their functions.

1.3 General characteristics of cell

Each cell in the body : -

1. Needs nutrition and oxygen.
2. Produces its own energy necessary for its growth repair and other activities.
3. Eliminates carbon dioxide and other metabolic wastes.
4. Maintains the medium, that is, the environment for its survival.
5. Shows immediate response to the entry of invader like bacteria or toxic substances into the body.
6. Reproduces by division. There are some exceptions like neuron, which do not reproduce.

1.4 Structure of the cell

Each cell is formed by a cell body and a membrane covering the cell body called the cell membrane. Cell body has two major parts-the nucleus and the cytoplasm. The nucleus is separated from the cytoplasm by a nuclear membrane and the cytoplasm is separated from the surrounding fluids by a cell membrane.

The different substances that make up the cell are collectively called protoplasm. Protoplasm protoplasm is composed mainly of five basic substances: - water, electrolytes proteins, lipids and carbohydrates.

The cell is a bag of fluid, enzymes and chemicals, it also contains highly organized physical structures, many of which are called organelles.

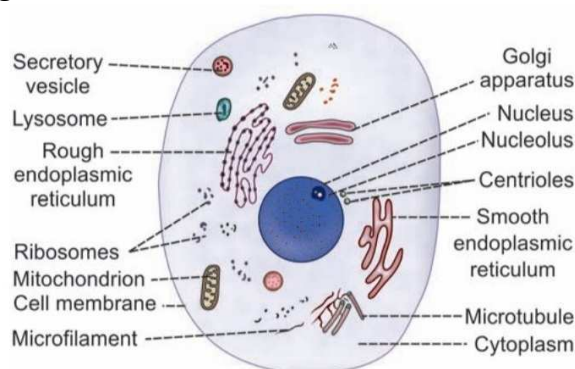


Figure 1.1 Structure of the cell

Membranous structures of the cell:-

Most organelles of the cell are covered by membranes composed mainly of lipids and Proteins. These membranes include the cell membrane, nuclear membrane membrane of endoplasmic reticulum, and membranes of mitochondria, lysosomes and Golgi apparatus.

The lipids of the membranes provide a barrier that prevents movement of water and water soluble substances from one cell compartment to the other because the water is not soluble the lipids Protein molecules often penetrate all the way through the membrane, providing specialized pathways, often called pores, for passage of specific substances through the membrane. Many other membrane proteins are enzymes that catalyze different chemical reactions.

1.3.1 Cell Membrane:-

Cell membrane is a protective sheath, enveloping the cell body. The membrane separates the fluid outside the cell called extra-cellular fluid (ECF) & the fluid inside the cell called intra cellular fluid (ICF). The cell membrane is semi-permeable membrane. So there is free exchange of certain substances between ECF and ICF. Cell membrane is composed of proteins, lipids and carbohydrates.

1) Lipids layers of the cell membrane:-

Basic structure of the cell membrane is a lipids bilayer, which is. a. thin film of lipids that is continuous over the entire cell surface interspersed in this lipids film are large protein molecules. The characteristic feature of lipid layer is that, it is fluid in nature. So the portions of the membrane move from one point to another point along the surface of the cell. The materials dissolved in lipid layer also move to all areas of the cell membrane. Major lipids are-phospholipids and cholesterol.

a) Phospholipids :-

Phospholipids are the lipid substances contains phosphorus and fatty acids. Phospholipid molecules are arranged in two layers The outer part of phospholipid molecules is head portion and inner portion is tail portion. Head portion is soluble in water and has strong affinity for water (hydrophilic Tail portion is insoluble in water and repelled by water (hydrophobic).

b) Cholesterol:-

Cholesterol molecules are arranged in between the phospholipid molecules. Cholesterol helps to pack the phospholipids in the membrane. So, Cholesterol is responsible for the structural integrity of lipid layer of the cell membrane.

2) Protein layer of the cell membrane :-

Protein layers cover the two surfaces of the central lipid layer. Protein layers give protection to the central lipid layer. The protien substances present in these layers are mostly glycoproteins.

Protein molecules are classified into 2 categories.

- Integral Proteins
- Peripheral Proteins

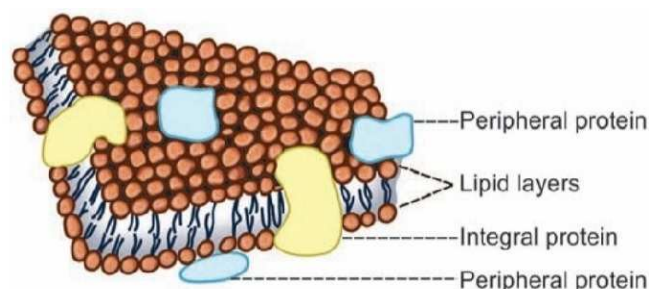


Figure 1.2 Structure of the cell membrane

a) Integral Proteins –

These proteins pass through entire thickness of cell membrane from one side to the other side. These proteins are tightly bound with the cell membrane.

b) Peripheral Proteins –

These proteins are partially embedded in the outer and inner surfaces of the cell membrane. These are loosely bound with integral proteins or lipid layer of cell membrane. So, these protein molecules dissociate readily from cell membrane.

3) Carbohydrates of cell membrane -

Some of the carbohydrate molecules present in cell membrane are attached to proteins and form glycoproteins. Some carbohydrate molecules are attached to lipids and form glycolipids.

Carbohydrate molecules form a thin and loose covering over the entire surface of cell membrane.

1.3.2 Functions of cell membrane:

1. Protective function: It protects the cytoplasm and the organelles present in the cytoplasm.
2. Selective permeability: It acts as a semipermeable membrane, which allows only some substances to pass through it and acts as barrier for other substances.
3. Absorptive function: Nutrients are absorbed into the cell through the cell membrane.
4. Excretory function: Metabolites and other waste products from the cell are excreted out through the cell membrane.
5. Exchange of gases: Oxygen enters the cell from the blood and carbon dioxide leaves the cell and enters the blood through the cell membrane.
6. Maintenance of shape and size of the cell- Cell membrane is responsible for the maintenance of shape and size of the cell.

1.4 Cytoplasm:

Cytoplasm of the cell is the jelly-like material formed by 80% of water. It contains clear liquid portion called cytosol and various particles of different size and shape. Cytoplasm also contains many organelles with distinct structure and function.

Cytoplasm is made up of two zones-

- 1) Ectoplasm: Peripheral part of cytoplasm, situated just beneath the cell membrane.
- 2) Endoplasm: Inner part of cytoplasm, present between the ectoplasm and the nucleus.

1.4.1 Organelles in the cytoplasm:

1. Endoplasmic Reticulum : -

It is a network of tubular and vesicular structures which are interconnected with one another. It is covered by a limiting membrane, made up of proteins & bilayered lipids. The lumen of endoplasmic reticulum contains a fluid medium called endoplasmic matrix.

Types of endoplasmic reticulum.

- a. Rough Or Granular
- b. Smooth Or Agranular

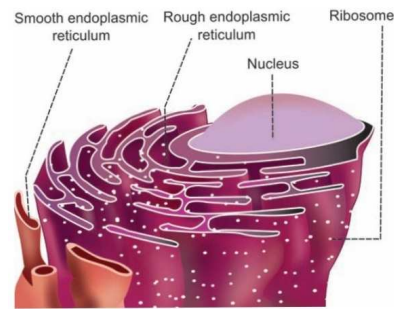


Figure 1.3 Endoplasmic reticulum

a. Rough endoplasmic reticulum: -

It is the endoplasmic reticulum with rough or bead like appearance. Rough appearance is due to attachment of granular ribosomes to its outer surface. Hence, it is also called the granular endoplasmic reticulum.

Functions of rough endoplasmic reticulum.

- Synthesis of proteins.
- Degradation of worn-out organelles.

b. Smooth endoplasmic reticulum :-

It is the endoplasmic reticulum with smooth appearance. It is also called agranular endoplasmic reticulum. It is formed by many interconnected tubules and hence known as tubular endoplasmic reticulum.

Function of smooth endoplasmic reticulum –

- Synthesis of non-protein substances.
- Role in cellular metabolism
- Storage and metabolism of calcium.
- Catabolism and detoxification.

2. Golgi apparatus:

Golgi apparatus or Golgi body or Golgi complex is a membrane bound cell organelle. It is present in all the cells except red blood cells. It is usually composed of four or more stacked layers of thin, flat, enclosed vesicles lying near one side of the nucleus. This apparatus is prominent in secretory cells.

Functions of Golgi apparatus -

- It functions in association with the endoplasmic reticulum.
- Substances entrapped in endoplasmic reticular vesicles are transported from endoplasmic reticulum to the Golgi apparatus. The transported substances are then processed in it to form lysosomes, secretory vesicles or other cytoplasmic components.
- Major functions of Golgi apparatus are processing, packing, labelling and delivery of proteins and other molecules like lipids to different parts of cell.

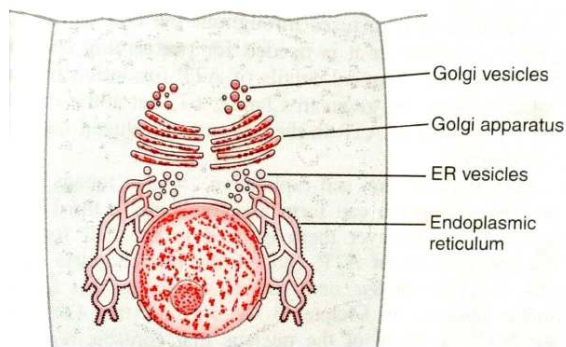


Figure 1.4 Golgi apparatus

3. Lysosomes : -

Lysosomes are the membrane bound vesicular organelles found throughout the cytoplasm. The lysosomes are formed by Golgi apparatus. The enzymes synthesized in rough endoplasmic reticulum are processed and packed in the form of small vesicles in Golgi apparatus. Then these vesicles are pinched off from Golgi apparatus and become the lysosomes. Among the organelles of the cytoplasm, the lysosomes have the thickest covering membrane. The membrane is formed by bilayered lipid material.

Functions of Lysosomes :- Lysosomes are often called “garbage system” of the cell, because of their degradation activity.

The lysosomes provide an intracellular digestive system that allows - the cell to digest within itself-

- damaged cellular structures.
- food particles that have been ingested by cell.
- unwanted matter such as bacteria.

Lysosomes having secretory function called secretory lysosomes are found in some of the cells, particularly in the cells of immune system.

4. Peroxisomes: -

Peroxisomes are physically similar to lysosomes but they are different in two important ways-first, they are believed to be formed by self, replicating or by budding off from smooth endoplasmic reticulum rather than by Golgi apparatus. Second, they contain oxidases rather than hydrolases.

Functions of peroxisomes :-

- Breakdown the fatty acids by means of a process called beta-oxidation.
- Degrade the toxic substances such as hydrogen peroxide and other metabolic products by means of detoxification.
- Form the major site of oxygen utilization in the cells.
- Accelerate gluconeogenesis from fats.
- Degrade purine to uric acid.
- Participate in the formation of myelin.
- Play the role in the formation of bile acids.

5. Secretory Vesicles :-

Secretory vesicles are the organelles with limiting membrane and contain the secretory substances.

These vesicles are formed in the endoplasmic reticulum and are processed and packed in Golgi apparatus. When necessary, these vesicles are ruptured and secretory substances are released into the cytoplasm.

6. Mitochondrion (Plural-mitochondria): -

Mitochondria are membrane bound cell organelles, known as “powerhouses” of the cell. Without them, the cells would be unable to extract significant amounts of energy from the nutrients, and as a consequence, essentially all cellular functions would cease.

Mitochondria are present in all areas of each cells cytoplasm. The basic structure of the mitochondrion is composed mainly of two lipid bilayer-protein membranes : an outer membrane and an inner membrane. Many infoldings of the inner membrane form shelves onto which oxidative enzymes are attached. The inner cavity of the mitochondrion is filled with a matrix that contains large quantities of dissolved enzymes that are necessary for extracting energy from nutrients. These enzymes operate in association with the oxidative enzymes on the shelves to cause oxidation of the nutrients, thereby forming carbon dioxide and water and at the same time releasing energy. The liberated energy is used to synthesize a high energy substance called ATP (Adenosine triphosphate). The ATP is then transported out of the mitochondrion, and it diffuses through the cell to release its energy whenever it is needed for performing cellular.

Mitochondria are self replicative, which means that one mitochondrion can form a second one, a third one, and so, on, whenever there is need in the cell for increased amounts of ATP.

Mitochondria contain deoxyribonucleic acid (DN similar to that found in the nucleus. The DN of the mitochondria plays a similar role in the mitochondrion for controlling its own replication.

Functions of mitochondria :-

- Production of energy.
- Synthesis of ATP
- Apoptosis - It is defined as the natural or programmed death of the cell under genetic control.
- Organelle's without limiting membrane :-

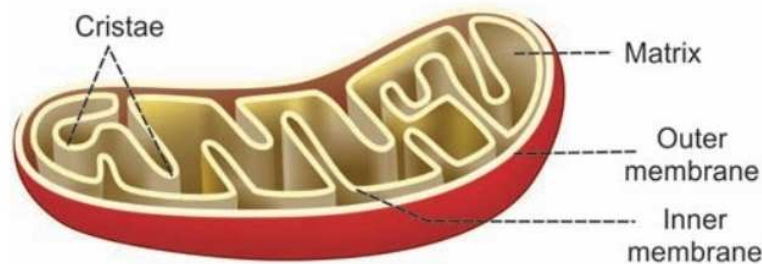


Figure 1.5 Stucuture of Mitochondrion

7. Ribosomes :-

Ribosomes are the organelles without limiting membrane. These are granular and small dot like structures. They are made up of 35% proteins and 65% of ribonucleic acid (RNA). RNA present in ribosomes is called ribosomal RNA (rRNA). Ribosomes are concerned with protein synthesis in the cell.

Types :-

- i) Ribosomes that are attached to rough endoplasmic reticulum.
- ii) Free ribosomes that are distributed in cytoplasm.

Function :-

- Protein factories :Plays role in protein synthesis.
- Ribosomes attached to rough endoplasmic reticulum are involved in synthesis of proteins such as the enzymatic proteins, hormones proteins.
- Free ribosomes are responsible for synthesis of proteins in haemoglobin, peroxisome and mitochondria.

8. Cytoskeleton :-

Cytoskeleton is the cellular organelle present throughout the cytoplasm.

It determines the shape of the cell and gives support to the cell. s

It is essential for the cellular movements and the response of the cell to the external stimuli. It consists of 3 major protein components.

- i) Microtubule
- ii) Intermediate filaments
- iii) Microfilaments

9. Nucleus: -

Nucleus is the most prominent and the largest cell organelle. It is present in all the cells in the body except the red blood cells. Most of the the cells have only one nucleus. Few types of cells like skeletal muscle cells have many nuclei.

Generally, the nucleus is located in the centre of the cell.

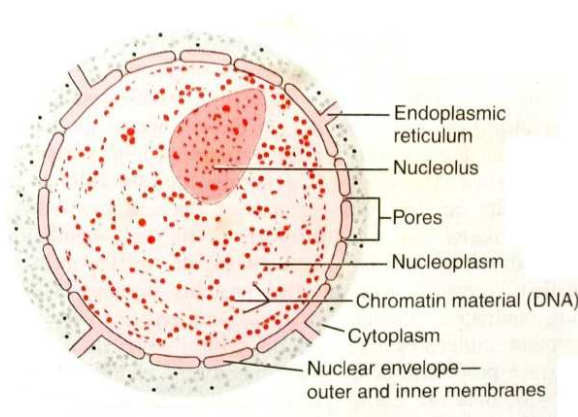


Figure 1.6 Stucuture of Nucleus

Structure of the Nucleus: -

Nucleus is covered by a membrane called nuclear membrane and contains many components. Major components of nucleus are nucleoplasm, chromatin and nucleolus.

Nuclear membrane: -

It is double layered and porous in nature. This allows the nucleoplasm to communicate with the cytoplasm. The outer layer of nuclear membrane is continuous with the membrane of endoplasmic reticulum. The space between two layers of nuclear membrane is continuous with the lumen of endoplasmic reticulum. Pores of nuclear membrane are guarded by protein molecules. Exchange of materials between nucleoplasm and cytoplasm occurs through these pores.

Nucleoplasm: -

It is highly viscous fluid that forms the ground substance of the nucleus. It is similar to cytoplasm present outside the nucleus.

It surrounds chromatin and nucleolus. It contains dense fibrillary network of proteins called the nuclear matrix and many substances like nucleotides and enzymes.

Chromatin: -

It is thread like material made up of large molecules of DNA. The DNA molecules are compactly packed with the help of specialized basic protein called histone. So, chromatin is referred as DNA-histone complex. It forms the major bulk of nuclear material.

Chromosomes: -

Chromosome is the rod-shaped nuclear structure that carries a complete blueprint of all the hereditary characteristics of that species.

A chromosome is formed from a single DNA molecule coiled around histone molecules. Each DNA contains many Genes.

10. Nucleolus: -

It is a small, round, granular structure of the nucleus. Each nucleus contains one or more nucleoli. The nucleolus contains RNA and some proteins.

1.4.2 Functions of nucleus: -

- Control of all the cell activities that include metabolism, protein synthesis, growth and reproduction (cell division).
- Synthesis of RNA.
- Formation of subunits of ribosomes.

- Sending genetic instruction to the cytoplasm for protein synthesis.
- Control of the cell division Through Gene.
- Storage of hereditary information (in genes) and transformation of this information from one generation of the species to the next.

1.5 DNA and RNA

DNA (Deoxyribonucleic Acid) :-

It is nucleic acid that carries the genetic information to the off spring of the organism. It forms the chemical basis of hereditary characters. It contains the instruction for the synthesis of proteins in the ribosomes. Gene is a part of DNA molecule.

DNA is present in the nucleus and mitochondria of cell. The DNA present in the nucleus is responsible for the formation of RNA regulates the synthesis of proteins by ribosomes. DNA in mitochondria is called non-chromosomal DNA. DNA forms the component of chromosomes, which carries the hereditary information.

Gene: -

Gene is a portion of DNA molecule that contains the message or code for synthesis of a specific protein from amino acids. It is like a book that contains the information necessary for protein synthesis. Gene is considered as the basic hereditary unit of the cell.

RNA (Ribonucleic Acid) :-

It is nucleic acid that contains a long chain of nucleotide units. It is similar to DNA but contains ribose instead of deoxy-ribose. Various functions coded in the genes are carried out in the cytoplasm of the cell by RNA. RNA is formed from DNA.

Types of RNA- 1) Messenger RNA (mRNA) 2) Transfer RNA (tRNA) 3) Ribosomal RNA (rRNA)

1.6 Summary

In this chapter we studied, Cell is the structural and functional unit of the living body. Each cell in the body performs various functions including nutrition, protection and reproduction. Cell body and a membrane covering the cell body together form a cell. Cell contains different cell organelles which perform various functions. Cells are often called as “building blocks of life”.

A tissue is a group of cells, in close proximity, organized to perform one or more specific functions. There are four basic tissue types defined by their morphology and functions - epithelial tissue, connective tissue, muscle tissue and nervous tissue.

1.7 Glossary

- Tissue – The mass of similar cells in animal or plant body.
- Organelle – A specialized subunit within a cell that has a specific function and is usually separately enclosed within its own membrane.
- Cell membrane – The thin layer of protein and fat that surround the cell. The cell membrane is semi permeable allowing some substances to pass into the cell and blocking other.
- Cytoplasm – The jelly like material outside the cell nucleus in which the organelles are located.
- Mitochondrion – Spherical to rod shaped organelles with a double membrane. The inner membrane is infolded many times, forming a series of projections (called cristae). The mitochondrion converts the energy stored in glucose into ATP (Adenosine triphosphate).
- Golgi body/Golgi apparatus/Golgi complex – A flattened, layered, sac-like organelle that looks like a stack of pancakes and is located near the nucleus. It Produces the membrane that surround the lysosomes. The Golgi body packages proteins and carbohydrates into membrane bound vesicles for “export” from the cell.

- Lysosome (Cell vesicles) – Spherical organelles surrounded by a membrane they contain digestive enzymes. This is where the digestion of cell nutrients takes place.
- Nuclear membrane – The membrane that surrounds the nucleus.
- Nucleus – Spherical body containing many organelles, including the nucleolus. The nucleus controls many of the functions of the cell (by controlling protein synthesis) and contains DNA (in chromosomes). The nucleus is surrounded by nuclear membrane.
- Nucleolus – An organelle within the nucleus it is where ribosomal RNA is produced. Some cells have more than one nucleolus.
- Chromosome – One of the tiny, thread like, DNA containing bodies found in the cell nuclei of all plants and animals, responsible for transmitting hereditary characteristics.
- Ribosome – Small organelles composed of RNA rich cytoplasmic granules that are sites of protein synthesis.
- Rough endoplasmic reticulum (rough ER) – A vast system of interconnected, membranous infolded and convoluted sacs that are located in the cell's cytoplasm (the ER is continuous with the outer nuclear membrane). Rough ER is covered with ribosomes that give it a rough appearance. Rough ER transports materials through the cell and produces proteins in sacs called cisternae (which are sent to the Golgi body, or inserted into the cell membrane).
- Smooth endoplasmic reticulum (smooth ER) – A vast system of interconnected, membranous, infolded and convoluted tubes that are located in the cell's cytoplasm (the ER is continuous with the outer nuclear membrane). The space within the ER is called ER lumen smooth ER transports materials through the cell. It contains enzymes and produces and digests lipids (fats) and membrane proteins. Smooth ER buds off rough ER, moving the newly-made proteins and lipids to the Golgi body, lysosomes and membranes.

1.8 Answer to Questions (Multiple Choice Questions)

Cell

- 1) Cell is –
 - a) Structural unit of living body
 - b) Functional unit of living body
 - c) Both a & b
 - d) None
- 2) Which of the following is known as garbage system of cell.
 - a) Golgi apparatus
 - b) Endoplasmic reticulum
 - c) Lysosomes
 - d) Ribosomes
- 3) Which is the largest cell organelle
 - a) cell membrane
 - b) cytoplasm
 - c) Nucleus
 - d) Nuclear membrane.
- 4) DNA is present in
 - a) RNA
 - b) Nucleus
 - c) Mitochondria
 - d) both b & c
- 5) Basic hereditary unit of the cell is
 - a) Gene
 - b) DNA
 - c) RNA
 - d) DNA & RNA

Tissue

- 1) Tissue is -
 - a) A group of cells
 - b) A group of cell organelles
 - c) A group of organs
 - d) None
- 2) Squamous, cuboidal and columnar are types of -
 - a) Connective tissue
 - b) Epithelial tissue
 - c) Muscular tissue
 - d) Nervous tissue

- 3) Osteoblasts, osteocytes and osteoclasts are present in -
 a) Cartilage b) Blood c) Muscle d) Bones
- 4) Actin and myosin are components of
 a) Bones b) Muscle tissue c) blood d) Bone
- 5) Skeletal muscle is responsible for
 a) Voluntary movement b) Involuntary movements
 c) Both d) None

1.9 Reference Books

1. Essentials of Medical Physiology, K. Sembulingam.
2. Textbook of Medical Physiology, A. Guyton and J. Hall.
3. Histology : A text and Atlas, M. H. Ross.

1.10 Question Bank

1. Describe cell in detail with suitable diagrams
2. Describe structure and functions of human cell with suitable diagramme.
3. Short notes- i) Golgi body ii) Mitochondria iii) Lysosome

Questions: -

1. What is tissue? Explain the classification of tissue in detail.
2. Explain connective tissue in detail.
3. Short Questions- i) Functions of epithelial tissue. ii) Classification of connective tissue.

Chapter - 2

The musculoskeletal System

2.1 Preface

The musculoskeletal System is composed of two systems. The muscular system and the skeletal system but is commonly referred to as 'musculoskeletal' because of their main common functions. Which are movement and support.

The musculoskeletal System is made up of hard and soft tissues. The hard tissues include bones and cartilages (articular cartilages), while the soft tissues are the muscles, tendons, synovial membranes, joint capsule and ligaments.

2.2 Objectives

- What is musculoskeletal system?
- Functions of musculoskeletal system.
- Components of musculoskeletal system.
- Classification of muscles.
- General characteristics of Tendons, ligament synovial membrane, joint capsules.
- Skeletal system – general characteristics, functions .
- Bone structure.
- Types of bones
- Human Skeleton.
- Joints, classification, movements of joints.

2.3 The muscular system: -

Muscles :- Muscles are the largest soft tissues of the musculoskeletal system. The muscle cells muscle fibres - produce contractions that move body parts, including internal organs. Associated connective tissue binds muscle fibres in fascicles or bundles, and these associated connective tissues also convey nerve fibers and blood vessels to the muscle cells.

2.4 Classification of muscles-

Muscles are classified by three different methods, based on different factors.

- Depending upon the presence and absence of striations.
- Depending upon the control.
- Depending upon the location.
- Depending upon striations :- Histologically, muscles are divided into two types-
 - 1) striated Muscles
 - 2) Non-striated Muscles

1. Striated Muscles -

Striated Muscle is the muscle which has large number of cross striations (transverse lines). This structural characteristic (striation) is due to the way the filaments of actin and myosin are arranged in each of the classes of muscles.

Skeletal muscles and cardiac muscles belong to this category.

2. Non-Striated muscles -

Muscle which does not have cross striations is called non-striated muscle. It is also known as plain muscle or smooth muscle.

It is found in the wall of visceral organs.

ii. Depending upon control - Depending upon control, the muscles are classified into two types.

1. Voluntary muscles
2. Involuntary muscles

1. Voluntary muscles- The muscle which is controlled by will is called.

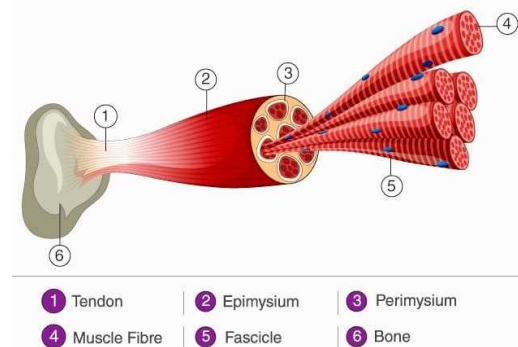


Figure 2.1 Structure of A Skeletal Muscle

1. Skeletal muscles -

Skeletal Muscle is situated in association with bones forming the skeletal system. The skeletal muscles form 40% to 50 % of body mass and are voluntary and striated.

The best known feature of skeletal muscle is its ability to contract and cause movement. Skeletal muscles act not only to produce movement but also to stop movement. Such as resisting gravity to maintain posture, small, constant adjustments of the skeletal muscle are needed to hold a body upright or balanced to any position. Muscles also prevent excess movements of bones and joints, maintaining skeletal stability and preventing skeletal structure damage or deformation. Joints can become misaligned or dislocated entirely by pulling on the associated bones: (muscles work to keep joints stable). Skeletal muscles are located throughout the body. These muscles allow functions, such as swallowing, urination, defecation. Skeletal muscles also protect internal organs (particularly abdominal and pelvic organs) by acting as an external barrier or shield to external trauma and by supporting the weight of the organs.

Skeletal muscles contribute to the maintenance of homeostasis in the body by generating heat. Muscle contraction requires energy and when ATP is broken down, heat is produced. This heat is very noticeable during exercise, when sustained muscle movement causes body temperature to rise, and in case of extreme cold, when shivering produces random skeletal muscle contractions to generate heat.

Each skeletal muscle is an organ that consists of various integrated tissues. These tissues include the skeletal muscle fibers, blood vessels, nerve fibers and connective tissue. Each skeletal muscle has three layers of connective tissue that enclose it and provide structure to the muscle as a whole, and also compartmentalize the muscle fibers within the muscle. Each muscle is wrapped in a sheath of dense, irregular connective tissue called the epimysium, which allows a muscle to contract and move powerfully while maintaining its structural integrity. The epimysium also separates muscle from other tissues and organs in that area, allowing the muscle to move independently. Inside each skeletal muscle, muscle fibers are organized into individual bundles, each called a fascicle, by a middle layer of connective tissue called the perimysium. This fascicular organization is common in muscles of the limbs: it allows the nervous system to trigger a specific movement of muscle by activating a subset of muscle fibers within a bundle, or fascicle of the muscle. Inside each fascicle, each muscle fiber is encased in a thin connective tissue layer of collagen and reticular fibers called the endomysium. The endomysium contains the extracellular fluid and nutrients to support the muscle fiber. These nutrients are supplied via blood to the muscle tissue.

In skeletal muscles that work with tendons to pull on bones, the collagen in the three tissue layers (epi, peri and endomysia) intertwines with the collagen of a tendon. At the other end of tendon, it fuses with the periosteum coating the bone. The tension created by contraction of the muscle fiber is then transferred through the myofibrils, to the tendon, and then to the periosteum to pull on the bone for movement. In some places, the myofibrils may fuse with a broad, tendon-like sheet called an aponeurosis, or to fascia, the connective

tissue between skin and bones. The broad sheet of connective tissue in the lower back that the latissimus dorsi muscles fuse into is an example of aponeurosis.

Another specialization of the skeletal muscle is the site where a motor neuron's terminal meets the muscle fiber-called the neuromuscular junction. This is where the muscle fiber first responds to signalling by the motor neuron. Every skeletal muscle fiber in every skeletal muscle is innervated by a motor neuron at the neuromuscular junction. Excitation signals from the neuron are the only way to functionally activate the fiber to contract.

The skeletal muscles have following properties-

- Extensibility: It is the ability of the muscles to extend when it is stretched.
- Elasticity: It is the ability of the muscle to return to its original structure when released.
- Excitability: It is the ability of the muscle to respond to a stimulus.
- Contractility: It is the ability of muscle to contract when in contact with stimulus.

2. Cardiac muscles-

Cardiac muscles form the musculature of heart. Similar to skeletal muscle, cardiac muscle is striated. Cardiac muscle fibers are shorter than skeletal muscle fibers. Cardiac muscle fibers are extensively branched and are connected to one another at their ends by intercalated discs. An intercalated disc allows the cardiac muscle cells to contract in wave like pattern so that the heart can work as a pump. Contractions of the heart (heartbeats) are controlled by specialized cardiac muscle cells called pacemaker cells that directly control heart rate. Although cardiac muscle can not be consciously controlled, the pacemaker cells respond to signals from the autonomic nervous system to speed up or slow down the heart rate.

3. Smooth muscle -

Smooth muscle is situated in association with viscera. It is also called visceral muscle. It is different from skeletal and cardiac muscles because of the absence of cross striations, hence the name smooth muscle. Smooth muscle is present in walls of hollow organs like urinary bladder, uterus, stomach, intestines and in the walls of passageways, such as arteries and veins. Smooth muscle is also present in the eyes, where it functions to change the size of iris and alter the shape of lens, and in the skin where it causes hair to stand erect in response to cold temperature or fear. Smooth muscle is not under voluntary control. The triggers for smooth muscle contractions include hormones, neural stimulation by autonomic nervous system and local factors.

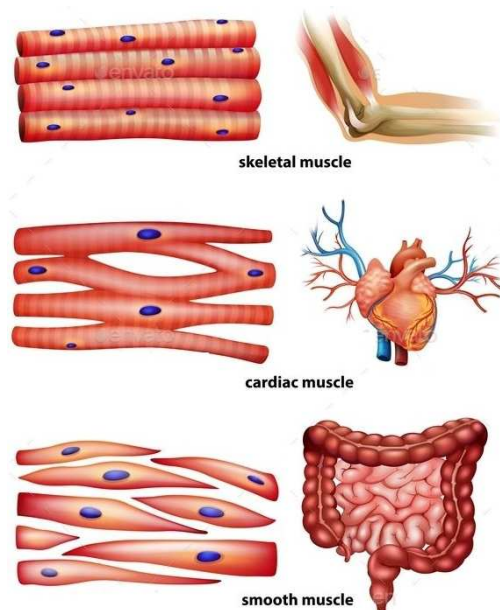


Figure 2.2 Types of Muscle Cells

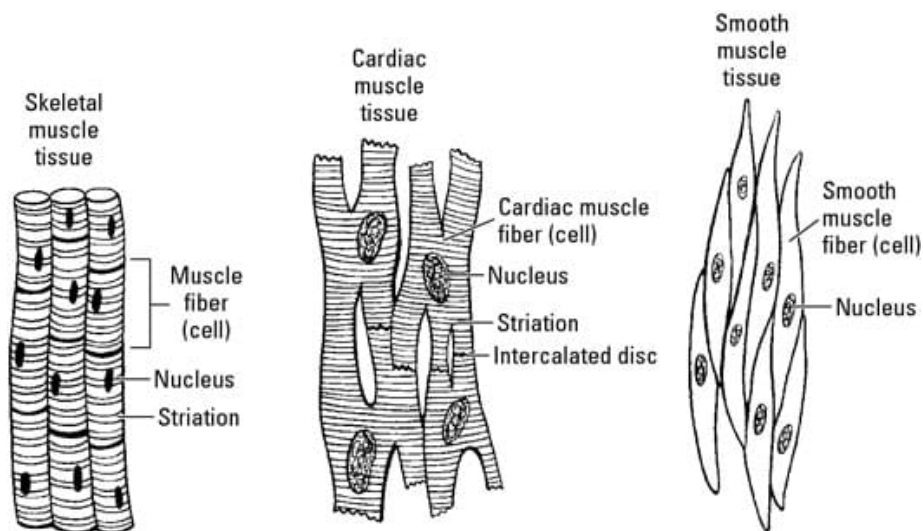


Figure 2.3 Types of Muscle Tissue

2.4.1 Tendons

A tendon is a tough, flexible bond of fibrous connective tissue that connects muscles to bones. The extracellular connective tissue between muscle fibers binds to tendons at the distal and proximal ends, and the tendon binds to the periosteum of bones at the muscle's proximal attachment to bone (origin) and distal attachment (insertion). As muscle contracts, tendon transmits the force to the bones, pulling on them and causing movement.

Tendons are remarkably strong, having one of the highest tensile strengths found among soft tissues. Their great strength, which is necessary for withstanding the stresses generated by muscular contractions is attributed to the hierarchical structure parallel orientation and tissue composition of tendon fibres. A tendon is composed of dense, fibrous connective tissue made up primarily of collagenous fibres. Tendons are bright white in colour; their fibro-elastic composition gives them the strength required to transmit large mechanical forces. Each muscle has two tendons, one proximally and one distally. The point at which the tendon forms attachment to the muscle is known as musculo, tendinous junction and the point at which it attaches to the bone is known as osteotendinous junction. The proximal attachment of the tendon is known as the origin and the distal tendon is called insertion.

Tendons have different shapes and sizes depending on the role of the muscle. Muscles that generate a lot of power and force tend to have shorter and wider tendons than those that perform more fine delicate movements. These tend to be long and thin.

Tendon is a comparatively poorly vascularised tissue that relies heavily upon synovial fluid diffusion to provide nutrition.

Nerve supply of tendon- The innervation of tendons start from cutaneous, peritendinous and muscular nerves.

2.4.2 Ligaments -

Ligaments are short bands of tough, flexible tissue, made up of lots of individual fibres, which connect the bones of the body together. The function of a ligament is to provide a passive limit to amount of movement between the bones. The human body has approximately 900 ligaments.

The basic building blocks of a ligament are collagen fibers. These fibers are very strong, flexible and resistant to damage from pulling or compressing stresses. Collagen fibers are usually arranged in parallel bundles, which help multiply the strength of the individual fibers.

Ligaments have the ability to adapt to the complex functions that each are required to perform once thought to be inert, they are in fact responsive to many local and systemic factors that influence their function.

Ligaments may be of two major types-white ligament is rich in collagenous fibers, which are sturdy and inelastic; and yellow ligament is rich in elastic fibres, which are quite tough even though they allow elastic movement.

Difference between tendon and ligament- Tendons connect bone to the muscle, while ligaments connect bone to other bone to form joint.

Blood supply - within the ligament, the blood vessels are located in the loose connective tissue that is located between longitudinal, fiber, bundles, compared to the surrounding synovial layer, the number of vessels is greatly reduced in ligament.

Nerve supply of ligaments- Nerves of the joint ramify on its ligaments and supply them most ligaments serve as sense organs because of their rich nerve supply. They act as important reflex mechanisms and are important in monitoring the position and movements of joints.

Ligaments are most often torn in traumatic joint injuries, that can result in either partial or complete ligament discontinuities.

2.4.3 Synovial membrane -

Synovial membrane line the synovial cavity and secrete synovial fluid that lubricates most joints where they are found (synovial joint) in order to reduce friction. The fluid secreted by a synovial membrane serves as source of nutrients for tendons and ligaments as well as to articular cartilages.

Synovial membrane is a layer of connective tissue that lines the cavities of joints, tendon sheaths and bursae and makes synovial fluid which has lubricating function. It plays major role in maintaining articular homeostasis by providing a pathway for the exchange of nutrients and metabolic by-products between blood and synovial tissue including articular cartilages. Hence, it is important part of musculoskeletal system.

2.4.4 Joint capsules -

Joint capsule is another most important part of musculoskeletal system. A joint capsule is composed of two or more layers of regular collagenous connective tissue forming a sleeve around the joint. The capsule holds the bones and other parts of the joint together. The joint capsule is vital to the function of synovial joints. It seals the joints space, provides passive stability by limiting movements, provides active stability via its proprioceptive nerve endings and may form articular surfaces for the joint.

2.5 Functions -

- Production of movement.
- Provide support to the body.
- Provide stability to joints.
- Productions of body heat.

2.6 The skeletal system -

The skeletal system is the organ system that provides an internal framework for the human body. Skeletal system includes bones, cartilages and ligaments.

Bones are organs made up of dense connective tissues, mainly the tough protein collagen. Bones contain blood vessels, nerves and other tissues. Bones are hard and rigid due to deposits of calcium and other mineral salts within their living tissues cartilage is a type of dense connective tissue, made of tough protein fibers. It is strong but flexible and very smooth. It covers the ends of bones at joints, providing a smooth surface for bones to move over.

Ligaments are bands of fibrous connective tissue that holds bones together. They keep the bones of skeleton in place.

Functions of skeletal system -

- 1) Support - The skeleton provides the framework which supports the body and maintains its shape.
- 2) Movement - The joints between bones allow movement. Movement is powered by skeletal muscles, which are attached to skeleton at various sites on bones. Muscles, bones and joints provide the principal mechanics for movement, all co-ordinated by nervous system.
- 3) Protection - The skeleton helps to protect many vital internal organs from being damaged. e.g. The skull protects brains, the vertebrae protects spinal cord.
- 4) Blood cell production - The skeletal is the site of hematopoiesis, the development of blood cells that takes place in the bone marrow. In children, hematopoiesis occurs primarily in the marrow of long bones. In adults, it occurs mainly in the pelvis, cranium, vertebrae and sternum.
- 5) storage - The bone matrix can store calcium and is involved in calcium metabolism. Bone marrow can store iron and is involved in iron metabolism.
- 6) Regulating of endocrine glands - The bone cells present within skeletal system plays an important role in releasing the synthesizes hormones from respective endocrine glands for further requirement by the body for different metabolisms.

2.7 Bone Structure

Bones are composed of two types of tissues-

1. Compact (cortical) bone :- A hard outer layer that is dense, strong and durable. It makes up around 80% of adult bone.
2. Cancellous (Trabecular or spongy) bone :- This consists of network of trabeculae or red like structure. It is lighter, less-dense and more flexible than compact bone.

We can also find –in bone-

- * Osteoblasts and Osteocytes-responsible for creating bone.
- * Osteoclasts-bone resorbing cells.
- * Osteoid- a mix of collagen and other proteins.
- * Inorganic mineral salts within the matrix.
- * Nerves and blood vessels
- * Bone marrow
- * Cartilage
- * Membranes-including the endosteum and periosteum.

2.7.1 Bone Cells –

There are three main types of cells-

- * Osteoblasts - These are responsible for making new bone and repairing older bone. Osteoblasts produce a protein mixture called osteoid, which is mineralized and becomes bones. They also manufacture hormones, including prostaglandine.
- * Osteocytes - These are inactive osteoblasts that have become trapped in the bone that they have created. They maintain connections to other osteocytes and osteoblasts. They are important for communication within bone tissue.
- * Osteoclasts - These are large cells with more than one nucleus. Their job is to break down bone. They release enzymes and acids to dissolve minerals in bone and digest them. This process is called resorption. Osteoclasts help remodel injured bones and create pathways for nerves and blood vessels to travel through.

2.7.2 Bone marrow-

Bone marrow is found in almost all bones. Where cancellous bone is present. The marrow is responsible for making around 2 million red blood cells every second. It also produces lymphocytes or white blood cells involved in the immune response.

Extracellular matrix –

Bones are essentially living cells embedded in a mineral-based organic matrix. This extracellular matrix is made of –

organic components, being mostly type-1 collagen. Inorganic components, including hydroxyapatite and other salts, such as calcium and phosphate.

Collagen gives bone its tensile strength, namely the resistance to being pulled apart, hydroxyapatite gives the bones compressive strength or resistance to being compressed.

2.8 Types of bones-

There are five types of bones in the human body.

1. Long bones - These are mostly complicated bone with little marrow and include most of the bones in the limbs. These bones tend to support weight and help movement.
2. Short bones - Only a thin layer of compact bone, these include bones of the wrist and ankle.
3. Flat bones - Usually bones that are thin and curved. They consist of two outer layer of compact bone and an inner layer of spongy bone. Flat bones include most of the bones of the skull and the sternum or breastbone. They tend to have a protective rule.
4. Sesamoid bones - These are embedded in tendons, such as patella or kneecap. They protect tendons from wear and stress.
5. Irregular bones - As their name implies, these are bones that do not fit into the first four categories and are having an unusual shape. They include the bones of spine and pelvis. They are often protecting organs or tissues.

2.9 Human Skeleton-

Human skeleton is the internal framework of the human body. It consists of 206 bones. The human skeleton can be divided into.

- 1) Axial Skelton
- 2) Appendicular Skeleton

1. Axial Skelton –

The axial skeleton forms the central axis of the human body. It consists of the skull, Vertebral column, thoracic cage, the ossicles of the ear, and hyoid bone of the throat.

Function of axial skeleton-

- The function of the axial skeleton is to provide support and protection to the brain, Spinal cord and organs in central cavity.
- It provides a surface for the attachment of muscles that move the head, neck and trunk. It also provides a surface for the attachment of muscles that perform respiratory movements.
- It stabilizes parts of appendicular skeleton.

a) The skull-

The bones of the skull support the structures of the face and protect the brain. The skull consists of 22 bones, which are divided into two categories- cranial bones and facial bones.

The cranial bones are eight bones that form the cranial cavity, which encloses the brain and serves as an attachment site for the muscles of the head and the neck.

The eight cranial bones include- the frontal bone, two parietal bones, two temporal bones, the occipital bone, the sphenoid bone and the ethmoid bone.

Fourteen facial bones from the face, provide cavities for the sense organs (Eyes, mouth and nose). Protect the entrances to the digestive and respiratory tracts, and serve as attachment points for facial muscles.

The fourteen facial bones are the nasal bones, maxillary bones, zygomatic bones, palatine, vomer, lacrimal bones, inferior nasal conchae and mandible.

The auditory ossicles of the ear transmit sounds from the air as vibrations to fluid-filled cochlea. The auditory ossicles consist of six bones-2 malleus bones, 2 incus bones and 2 stapes, one of each on each side.

The hyoid bone lies below the mandible in the front of the neck. It acts as a movable base for the tongue and is connected to muscles of the jaw, larynx and tongue.

The mandible articulates with the base of the skull, controlling the opening of airways and gut.

b) The Vertebral Column -

The Vertebral column surrounds and protects the spinal cord, supports the head and acts as an attachment point for the ribs and muscles of back and neck. It is comprised of 7 cervical vertebrae 12 thoracic vertebrae, 5 lumbar vertebrae, 5 sacral vertebrae (which are fused to form a sacrum) and 4 coccygeal vertebrae (which are fused to form a coccyx).

Each vertebral body has a large hole in the center through which the spinal cord pass. There is also a notch on each side through which the spinal nerves, which serve the body at that level, can exit from the spinal cord. The names of the spinal curves correspond to the region of the spine in which they occur. The thoracic and the sacral curve are concave while the cervical and the lumbar curve are convex. The arched curvature of the vertebral column increases its strength and flexibility, allowing it to absorb shocks like spring.

Intervertebral discs, composed of fibrous cartilage, lie between adjacent vertebral bodies from the second cervical vertebra to the sacrum. Each disc is part of a joint that allows for some movement of the spine, acting as cushion to absorb, shocks from movements, such as walking and running. Intervertebral discs also act as ligaments to bind vertebrae together.

c) The thoracic Cage :-

The thoracic cage, also known as rib cage, is the skeleton of chest. It consists of the ribs, sternum, thoracic vertebrae and costal cartilages. The thoracic cage encloses and protects the organs of the thoracic cavity, including the heart and lungs. It also provides support for the shoulder girdle and upper limbs, and serves as the attachment point for the diaphragm muscles of the back, chest and neck and shoulders. The sternum or breastbone, is a long, flat bone located at the anterior of the chest. It is formed from three bones that fuse in the adult. The ribs are 12 pairs of long, curved bones that attach to the thoracic vertebrae and curves toward the front of the body, forming the ribcage costal cartilages connect the anterior ends of the ribs to the sternum, with the exception of rib pairs 11 and 12, which are free floating ribs.

2) Appendicular Skeleton -

The human appendicular skeleton is composed of the bones of the upper limbs (which function to grasp and manipulate objects) and the lower limbs (which permit locomotion). It also includes the pectoral (or shoulder) girdle and the pelvic girdle, which attach the upper and lower limbs to the body respectively.

a) The pectoral girdle-

The pectoral girdle bones, providing the points of attachment of the upper limbs to the axial skeleton, consists of clavicle (or collar bone) in the anterior as well as the scapula (or shoulder blades) in the posterior.

The clavicles, s-shaped bones that position the arms on the body, lie horizontally across the front of the thorax (chest) just above the first rib.

The scapulae are flat, triangular bones that are located at the back of the pectoral girdle. They support the muscles crossing the shoulder joint.

The Upper limbs -

The upper limbs contain 30 bones in 3 regions the arm (shoulder to elbow), the forearm and the wrist and hand.

The humerus is the largest and longest bone of the upper arm and the only bone of arm. It articulates (joins) with the scapula at the shoulder and with the forearm at the elbow.

The forearm, extending from elbow to the wrist, consists of two bones- the ulna and the radius. The radius, located along the lateral (thumb)side of the forearm, articulated with the humerus at the elbow. The ulna, located on the medial aspect of forearm, is longer than radius. It articulates with the humerus at the elbow. The radius and the ulna also articulates with the carpal bones and with each other, which enables a variable degree of rotation of the carpus with respect to the long axis of the limb.

The hand includes the eight bones of carpals (wrist) the five bones of metacarpals (palm)and 14 bones of of phalanges (digits). Each digit consists of 3 phalanges, except for thumb, which has 2 phalanges.

b) The pelvic girdle

The pelvic girdle attaches to the lower limbs of the axial skeleton and is responsible for bearing weight of the body and for locomotion. It is securely attached to the axial skeleton by strong ligaments. It also has deep sockets with robust ligaments to securely attach the further strengthened by two large hip bones. In adults, the hip bones are formed by the fusion of 3 pairs of bones- the ilium, ischium and pubis. The pelvis joins together in the anterior of the body, the pubic symphysis joint and with the bones of the sacrum at the posterior of the body.

The Lower limbs -

The lower limbs consist of the thigh, the leg and the foot. The bones of the lower limbs are the femur (thigh bone), patella (knee cap), tibia and fibula (bones of leg), tarsals (bones of ankle), metatarsals and phalanges (bones of foot). The bones of the lower limbs are thicker and stronger than the bones of upper limbs because of the need to support the entire weight of the body along with the resulting forces from locomotion.

The femur or thigh bone, is the longest, heaviest and strongest bone in the body. The femur and pelvis form the hip joint at the proximal end. At the distal end, the femur, tibia and patella form the knee joint; it is embedded in the tendon of the femoral extensions (quadriceps). It improves knee extension by reducing friction.

The tibia, or shin bone, is a large bone of leg that is located directly below the knee. The tibia articulates with the femur at its proximal end, and with fibula and the tarsal bones at its distal end. As the second largest bone in the body, it is responsible for transmitting the weight of the body from the femur to the foot.

The fibula, or calf bone, parallels and articulates with the tibia. It is not weight-bearing, but acts as a site for muscle attachment while forming the lateral part of the ankle joint.

The tarsals are the seven bones of the ankle, which transmit the weight of the body from the tibia-fibula to the foot.

The metatarsals are the five bones of the foot, while the phalanges are 14 bones of toes.

2.9.1 Cartilage

Cartilage is an important component of the skeletal system. It is a firm tissue but is softer and much more flexible than bone.

Cartilage is a connective tissue found in many areas of the body including.

- Joints between bones e.g. elbow, knee, ankle
- Ends of ribs
- Between the vertebrae in the spine
- Ears and nose.
- Bronchial tubes or airways.

Cartilage is made up of specialized cells called chondrocytes. These chondrocytes produce large amounts of extracellular matrix composed of collagen fibres, proteoglycans and elastin fibers. There are no blood vessels in cartilage to supply the chondrocytes with nutrients. Instead, nutrients diffuse through a dense connective tissue. Surrounding the cartilage (called the perichondrium) and into the core of the cartilage. Due to lack of blood vessels cartilage grows and repairs more slowly than other tissues.

Cartilage types:- cartilage is categorized into 3 types;

1. Hyaline cartilage
2. Elastic cartilage
3. Fibro cartilage

1. Hyaline cartilage - This is a low friction, wear resistant tissue present within joints that is designed to bear and distribute weight. It is a strong, rubbery flexible tissue but has poor regenerative capacity. In a joint hyaline cartilage refers to articular cartilage.

2. Elastic cartilage (Yellow cartilage) - It is more flexible than hyaline cartilage and is present in the ear, larynx and epiglottis.

3. Fibro cartilage (White cartilage) - It is a tough and inflexible form of cartilage found in the knee and between vertebrae.

Functions of Cartilage -

- The main purpose of cartilage is to provide a framework on which bone deposition may begin.
- Another important purpose of cartilage is to cover the surfaces of joints, allowing bones to slide over one another, thus reducing friction and preventing damage. It also acts as a shock absorber.

Joints-

A joint is defined as a connection between two bones in the skeletal system.

2.9.2 Classification of joints: -

Joints can be classified by the type of the tissue present (fibrous, cartilaginous and synovial) and by the degree of movement permitted (Synarthrosis, amphiarthrosis, diarthrosis)

Classification by the type of tissue present :-

1) Fibrous joints

A fibrous joint is where the bones are bound by a tough, fibrous tissue. Fibrous joints can be further sub-classified into sutures, gomphosis and syndesmoses.

i) sutures - sutures are immovable joints (Synarthrosis) and are only found in between flat, plate like bones of skull. There is limited movements until about 20 years of age, after which they become fixed and immobile. At birth, these joints are not fused.

ii) Gomphosis - Gomphosis are also immovable joints. They are found where the teeth articulate with their sockets in the maxilla (upper teeth) or the mandible (lower teeth). The tooth is bound into its socket by the strong periodontal ligament.

iii) Syndesmoses - Syndesmoses are slightly movable joints (amphiarthrous). They are comprised of bones held together by an interosseous membrane. The middle radio-ulnar and middle tibio-fibular joints are examples of syndesmoses joint.

2) Cartilaginous joints

In a cartilaginous joint, the bones are united by fibrocartilage or hyaline cartilage.

There are two main types- Synchondroses (primary cartilaginous) and symphyses (secondary cartilaginous).

i) Synchondroses - In a synchondrosis, the bones are connected by hyaline cartilage. These joints are immovable (synarthrosis). An example of a synchondrosis is the joint between the diaphysis and epiphysis of a growing long bone.

ii) Symphyses - Symphysial joints are where the bones are united by a layer of fibro-cartilage. They are slightly movable (amphiarthrosic). Examples include the pubic symphysis and the joints between vertebral bodies.

3) Synovial joints

A synovial joint is defined by the presence of fluid-filled joint cavity contained within a fibrous capsule. They are freely movable (diarthroses) and are the most common type of joint found in the body.

Synovial joints can be sub-classified into several different types, depending on the shape of their articular surfaces and the movements permitted.

i) Hinge joint - It permits movement in one plane-usually flexion and extension.

Ex. Elbow joint, ankle joint, knee joint.

ii) Saddle joint - It is named as saddle joint due to its resemblance to a saddle on a horse's back. It is characterised by opposing articular surfaces with a reciprocal concave-convex shape. Ex. Carpometacarpal joint.

iii) Plane joint - The articular surfaces are relatively flat, allowing the bones to glide over one another. Ex. Acromio-clavicular joint.

iv) Pivot joint - It allows for rotation only. It is formed by a central bony pivot, which is surrounded by a bony-ligamentous ring. Ex. Proximal and distal radioulnar joints, Atlanto-axial joint.

v) Condylloid joint - It contains a convex surface which articulates with a concave elliptical cavity. They are also known as ellipsoid joints.

Ex. Wrist joint, metacarpophalangeal joints, metatarsophalangeal joints.

vi) Ball and socket joint - It is the joint where ball-shaped surface of one bone fits into the cup-like depression of another bone. It permits free movements in numerous axes. Ex. Hip joint, shoulder joint.

2.9.3 Movements of joints

i) Flexion/extension - The opposing movements of flexion and extension take place in sagittal directions around transverse axes. Flexion, or bending, involves decreasing the angle between the two entities taking part in the movement. Extension or straightening, involves increasing the respective angle.

Ex. In knee joint, during flexion, the leg moves backwards and during extension, it moves forwards. In elbow joint, during flexion the forearm moves upwards and closer to the arm. During extension forearm straightens increasing the angle relative to the arm.

In shoulder joint, during flexion, the arm moves anteriorly and upwards (in full flexion). During extension of arm, (from flexed position), the arm moves posteriorly and downwards, back to the anatomical position. If a full range of motion is performed, it can continue posteriorly, creating an imaginary arc or semi-circle. In ankle joint, flexion of foot is referred to as dorsiflexion. In dorsiflexion, front part of the foot is lifted while keeping the heel on the ground. Plantarflexion is flexion of the plantar (underside) part of the foot by moving it down. This movement happens when the person is standing on his toes or pointing them.

ii) Abduction / Adduction - The movements of abduction and adduction are intimately related to the median plane. They both generally occur in the frontal plane and are happening around an antero-posterior axis.

Ex. In shoulder /hip joint, during abduction, person is moving his arm /leg away from median plane. During adduction, person is moving them towards the median plane.

The digits of the hands and feet are also capable of abduction and adduction. During abduction, person is moving the digits away from third finger or second toe, hence spreading them apart from medial plane. Adduction is opposite- the digits are brought closer.

iii) Protrusion/retrusion - The movements of protrusion and retrusion take place in the sagittal plane. They are also related to the transverse axis, but instead of only moving around it, these movements are also taking place parallel to it. Protrusion involves a movement going straight ahead or forward. Retrusion is opposite and involves going backwards. Anatomical structures capable of such actions are the tongue chin

(mandible) and lips. During protrusion, mandible moves directly anteriorly (underbite). During retrusion, it moves directly posteriorly (Overbite).

iv) Depression/Elevation - In depression and elevation anatomical structures move downwards (inferiorly) and up words (superiorly) respectively.

During depression, mandible moves directly downwards. During elevation, it moves directly up wards. These movements are performed during chewing.

v) Lateral/medial Rotation - Rotation happens in the transverse plane around a supero-inferior (longitudinal) axis that happens relative to the median plane. Medial rotation involves bringing the anatomical structure closer to the median plane, while lateral rotation involves moving it further away. Although very similar, rotations are distinct from abductions/adductions, due to the planes the movements are happening in.

Ex. In head, these two movements happen by changing the position the nose is pointing to. Turning the head laterally corresponds to lateral rotation, while Turing it back to look straight ahead corresponds to medial rotation.

In arm/leg by bringing biceps/vast us muscles towards the midline, person is rotating them medially. If the person orients them in the opposite direction, he is rotating them laterally. During holding a new-born baby arms are medially rotated.

vi) Pronation/Supination - Pronation and supination are two special types of rotation. They are restricted to forearm and involve the radius twisting over the ulna. Supination is a lateral rotation of the radius, resulting in the palm of the hand faving anteriorly (in anatomical position) or superiorly (if elbow is flexed). In contrast, pronation is a medial rotation of the radius, with palm ending in opposite directions compared to supination.

vii) Circumduction - Circumduction is a special type of movement that is actually a combination of many other the overall movement starts with flexion, followed by abduction, extension and finally adduction. The order must be sequential, but it can start from either flexion or adduction. The result is a circular movement. Due to the multitude of movements, circumduction is restricted to ball and socket type joints, such as the shoulder and the hip.

viii) Deviation - Deviation is a special type of movement that is restricted to the wrist joint. Radial deviation involves the movement of the wrist to words the "thumb side ". Ulnar deviation consists of the moving the wrist towards the side of the little finger. As the angle between the hand and the forearm are reduced, deviation can be referred to as radial/ulnar flexion.

ix) Opposition/reposition - These two movements are restricted to the digits of the hand. Opposition involves touching any one of the finger with the thumb of the same hand. Reposition is the reverse, which consists of separating them.

x) Inversion / Eversion - In eversion the plantar side of the foot is moved away from the median plane, so that it is turned laterally. In inversion, the plantar side is moved towards the median plane, resulting in a medial turn.

2.10 Functions of musculoskeletal System :

Primarily, functions of musculoskeletal System are movement and support but the system also performs the following function-

- Protection of Vital structures
- Stability
- Storage of salts (eg. Calcium)
- Formation and supply of new blood cells.
- Maintenance of posture and body position.

2.11 Summary

Movement is characteristic of living beings and is important for its survival. This movement is a complex mechanism procured by specialised muscular tissues in the body. Our body, like buddings, stands on pillars called skeleton. Skeletal system comprises of bones in the body which are weight bearing and supporting units of the body.

In this chapter, we studied structural details and functional importance of these body parts.

2.12 Glossary

- Striations – When used in the context of the anatomy of muscle structures, the word striation refers to the stripe like visual features found in skeletal muscle. The visual features consist of alternating light and dark striations that can be observed using just a simple light microscope.
- Any of the alternating light and dark cross bands that are visible in certain muscle fibres, especially of voluntary muscles, and are produced by the distribution of contractile proteins.
- Voluntary – Proceeding From the will or from one's own choice or consent.
- Done in accordance with conscious will of the individual.
- Somatic nerves – The nerves which supply the limbs and body wall and which control the voluntary activities of the body.
- Visceral – Having to do with the viscera, which are the soft internal organs of the body, including the lungs, the heart and the organs of the digestive excretory, reproductive and circulatory systems.
- Felt in or as if in the internal organs of the body.
- Pacemaker cells – The cells that create the rhythmic impulses, setting the pace for blood pumping, are called pacemaker cells, and they directly control the heart rate.
- Proximal – Nearer to the center (trunk of the body) or to the point of attachment to the body.
- Toward the beginning, the nearer of two (more) items. For example – 1) The proximal end of femur is part of the hip joint. 2) The shoulder is proximal to the elbow.
- Distal – Located away from the center of the body. Distal refers to a body part that is farther, relative to another body part. For example – The distal end of the femur is the end down by the knee. The opposite of distal is proximal.

2.13 Answer to Questions (5 MCQ)

- 1) Which of the following are striated muscles -
 - a) skeletal muscles
 - b) cardine muscles
 - c) muscles in walls of visceral organs
 - d) both a & b
- 2) Tendons connect -
 - a) muscles to bones
 - b) Bones to bones
 - c) muscles to muscle
 - d) none
- 3) Human skeietan is divided into
 - a) Axial and appendicular skeleton
 - b) skull and appendicular skeleton
 - c) skull and vertebral column
 - d) None
- 4) Which are concave in shape -
 - a) cervical curve and sacral curve
 - b) thoracic curve and sacral curve
 - c) cervical and lumbar curve
 - d) None
- 5) Sutures are –
 - a) movable joints
 - b) Immovable Joints
 - c) Partially movable
 - d) None

2.14 Reference Books

1. Essentials of Medical Physiology, K. Sembulingam.
2. Textbook of Medical Physiology, A. Guyton and J. Hall.
3. Histology : A text and Atlas, M. H. Ross.

2.14 Questions -

1. What is musculo-skeletal system? Write in detail about muscular tissue.
2. Describe in details about type of joints.
3. Describe rib cage and tell about types of bone in body.
4. Write in detail about functions of muscle tissue.

Write short notes on -

- Ligaments
- Tendons
- Carpal bones
- Sacrum

UNIT - 2

UNIT-2

Chapter - 3 Cardio - Vascular & Respiratory System

3.1 Preface

This system includes

- Blood
- Heart
- Blood vessels

Blood act as a means of communication between different cells of body.

Heart which acts as a pump and blood vessels carries is the blood. Through the blood vessels blood is circulated throughout the body.

3.2 Objective

This system will help you to focus on

- Blood and Blood cells
- Function of Blood
- Structure of Heart
- Circulation of blood within heart.

3.3 The Blood

3.3.1 Blood Definition :-

The bright red colour fluid which flows through heart, vessels and provides oxygen and nourishment to the body cells.

The Human body contains about 5.5 liters of blood. Blood consist of liquid as well as solid part.

- The plasma - Liquid part of the blood.(55%)
- The Blood cells -Solid part of the blood. (45%/)

3.3.2 Types of Blood Cell

There are mainly two types of blood cells.

1. Red blood cells (RBC)
2. White blood cells (WBC)

Red Blood Cells :-

The red colour of blood cells is due to red pigment haemoglobin which carries oxygen molecules and iron. These cells formed in the bone marrow (end of the long bones).

Life span of each R.B.C. is 120 day. The average count of RBC in adult ranges from 4.5 to 5.5 million cells/mcL. Deficiency of R.B.Cs causes Anaemia.

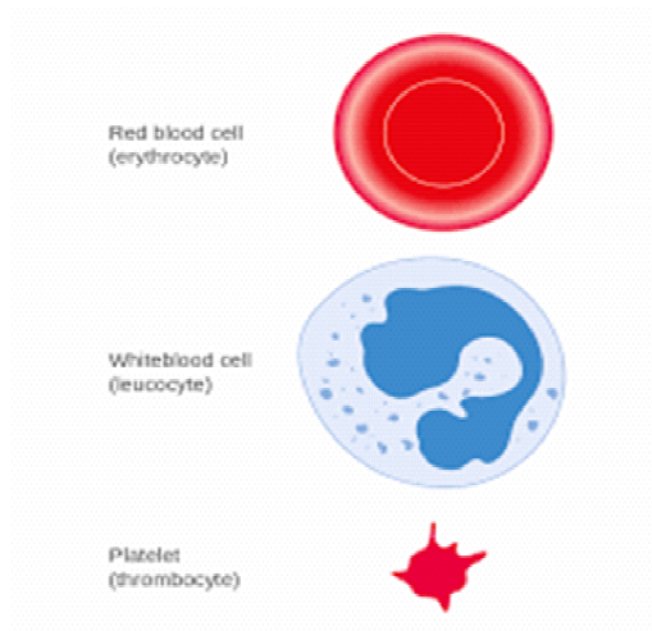
White blood cells (WBC):-

These cells are important part of immune system (defence mechanism). They kill the germs and protect the body from various infections.

Total number of WBCs in adult ranges from 5000 to 9000/mm of blood.

WBC are formed inside the bone marrow.

Blood cells diagram



3.3.3 Function of Blood

- It helps in transport of oxygen to cells of the body.
- Transport nutrient material from intestine to tissues.
- It helps in removal of waste material through kidneys.
- Acts as a medium for transportation of hormones, vitamins.
- Regulation of body temperature.
- Maintenance of water balance.
- Maintenance of Acid base balance.
- Regulate the blood pressure.

3.3.4 Blood Groups

There are total four different types of blood group.

- A
- B
- AB (Universal acceptor)
- O (Universal Donor)

3.3.5 Structure and functions of Heart

The Heart is an organ which acts as a pump through which blood circulates in the whole body.

Shape :- It is roughly cone shaped.

Size :- It differs from person to person usually a size of fist.

Weight :- 250 to 300 gms.

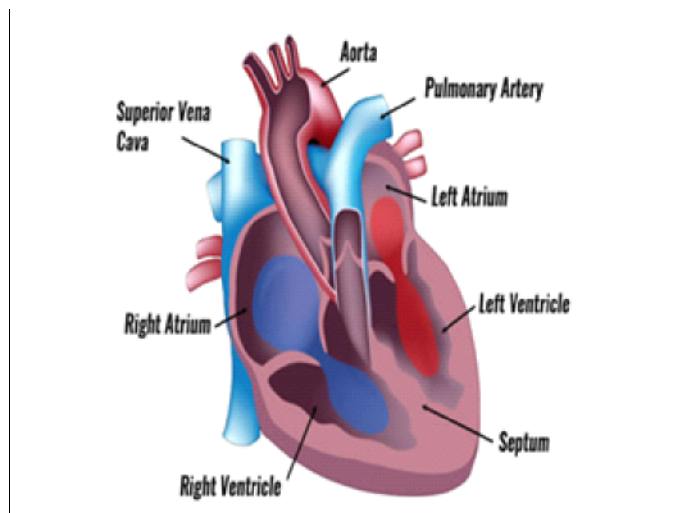
Position :- It is situated in chest (thoracic cavity) between two lungs. It lies more to the left side of the chest. The base of the heart is broad and present above and the apex is pointed and present below. (Left side)

3.3.6 Structure of the heart

The heart is divided into right and left half by a muscular septum. The human heart consists of total four (4) chambers.

- (2)Two atrium (present above)
- (2)Two ventricles (present below)

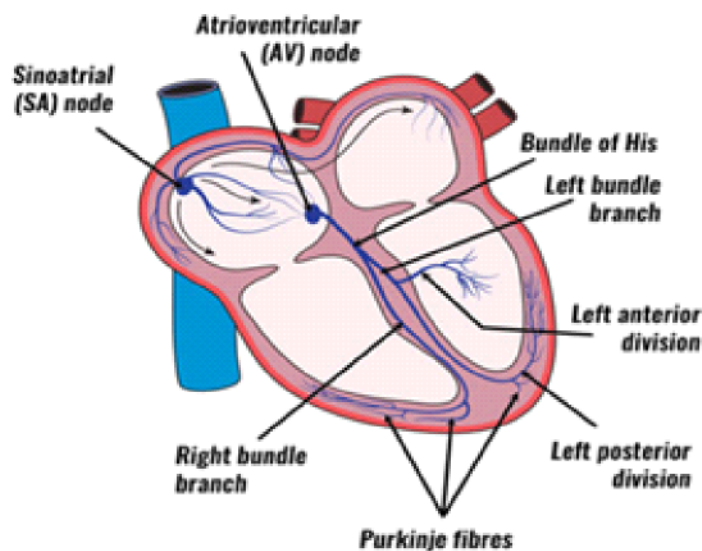
The blood enters into the heart through atrium. There are two valves made up of muscles present between atrium and ventricle on each side. (Right side tricuspid valve) (Left side bicuspid valve)



Structure of Heart

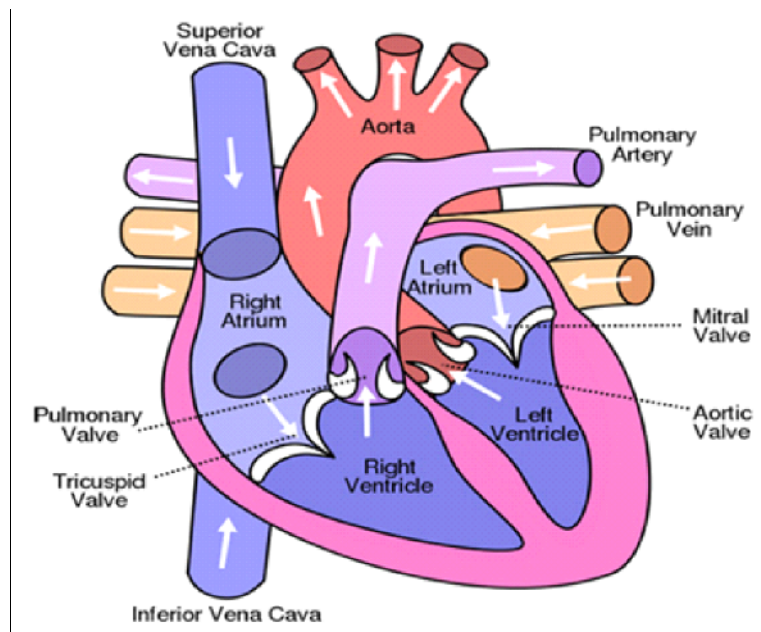
3.3.7 Functions of Heart

- The primary function of heart is to pump blood throughout the body.
- It supplies oxygen and nutrients to the tissues.
- It helps removes waste product of the blood.
- It helps to maintain normal blood pressure throughout body.
- Specialized group of muscles SA Node. AV Node forms conducting system of heart.
- These muscles transmit, electrical impulses which causes rhythmic beating of heart.



Conducting System of Heart

Circulation of blood in heart



Steps of cardiac cycle :-

- Impure blood (deoxygenated) enters into the right atrium from superior and inferior vena cava.
- Right atrium contracts and blood enters right ventricle through tricuspid valve which is situated in between right atrium and right ventricle.
- From right ventricle blood forced into pulmonary artery. This artery enter into the Lung where blood gets pured (oxygenated).
- This pure blood comes into left atrium through pulmonary vein(Normally arteries carries pure blood and veins carries impure blood but in cardiac cycle it is opposite).
- Through bicuspid value (which is present between left atrium and left ventricle) blood comes into the left ventricle.
- This pure blood oxygenated from left ventricle is forced into major artery of the body known as aorta.
- This Aorta divides into various arteries which supplies pure blood to the major part of body.

3.4.1 Blood pressure

The Blood pressure is defined as pressure exerted by the blood against the values of blood vessels (arteries and veins). This blood pressure is measured by instrument known as sphygmomanometer. (Blood pressure machine)

In Normal healthy human being the normal blood pressure range is 120/80 mm of Hg.

3.5 Summary

Detail study of CVS helps us to know about proper anatomical heart structure, its functioning, blood circulation to body organs. This system helps tissues get enough oxygen and nutrients and it helps to get rid of waste products. All blood cells forms from bone marrow and matures into RBCs WBCs and platelets. RBCs carries oxygen and plates prevents blood loss by forming clots at the site of injury and WBCs helps in defense mechanism of body by fighting against infection.

3.6 Glossary

PLASMA – Colorless liquid and part of blood in which the blood cells float.

VESSELS – Any of the tube in your body which blood flows through.

PIGMENT – A substance that gives color to things E.g. chlorophyll gives green color to plant and haemoglobin which gives red color to blood.

SEPTUM – Partition separating two chambers such as four chambers of heart.

3.7 Answer to questions

1. The red color of blood is due to
a) Iron b) RBCs c) Haemoglobin d) Oxygen
2. blood cells helps to fight against infection.
a) WBCs b) RBCs c) Platelets d) Plasma
3. The normal range of blood pressure.....
a) 110/80 mm of Hg b) 100/70 mm of Hg
c) 120 / 80 mm of Hg d) 150 /100 mm of Hg
4. The total duration of cardiac cycle is
a) 0.4 min. b) 1 min. c) 0.8 sec. d) 0.7 sec
5. Blood pressure measured by
a) Stethoscope b) Calimeter
c) Sphygmomanometer d) Thermometer

Ans :- 1) c 2) a 3) c 4) c 5) c

3.8 Reference Books

- 1) Human Anatomy & Physiology, For first year diploma in Pharmacy, Dr P.K. Puranik, By VBD publications Nagpur, Year 2003.
- 2) शरीरविद्यन परिचय, लीला ब. माडिवाले, अनंत प्रकाशन नागपूर, Third edition (2014).
- 3) शरीरशास्त्र व संलग्न आजार, जे. चिी. सफिया सिराज मोमिन, सिराजोशफि प्रकाशन कोल्हापूर, Fourth edition (2017).

3.9 Short Answer Questions

1. Functions of blood.
2. Different types of blood cells.
3. Functions of heart
4. Draw a labelled diagram of heart.

LONG ANSWER QUESTIONS

1. Describe in detail cardiac cycle.
2. Describe anatomy of Heart in detail

Chapter - 4

Respiratory System

4.1 Preface

Oxygen is a very important molecule for the function of human body. All chemical reaction which provides energy to the body takes place only in the presence of oxygen.

The respiratory system provides the route by which the oxygen from atmosphere enters into the body and it also provides the route for excretion of carbon dioxide into the atmosphere.

4.2 Objective

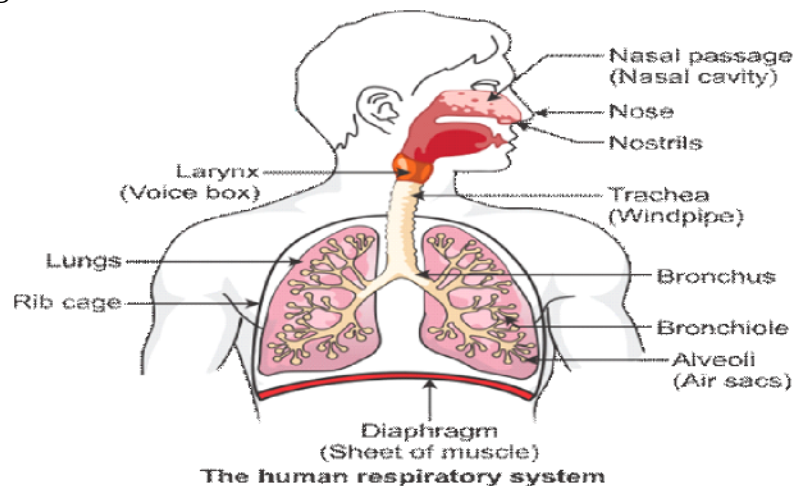
This system helps you to focus on organs of respiratory system.

- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs

4.3 Respiratory system / Respiration

The respiratory system includes all the structure which involve in the exchange of gases (O_2 and CO_2) between blood and external atmosphere.

Respiratory passage



4.4 Nose

The nose is an organ of olfaction (Smell). It consists of bony part which is divided into two nasal cavities. Nose is the first respiratory passage through which incoming air passes.

Nasal cavity is divided into two equal parts by a septum.

The nasal passage contains thin layer of hairs. Which acts as a filter.

4.4.1 Functions of Nose

- Warms and moistens the inspired (inhaled) air.
- Removes and traps pathogens /microbes from the inhaled air.
- Responsible for the sense of smell.
- The mucus glands present inside the nasal cavity secrete the mucus which helps to trap dust and pollutants coming from inhaled air.

4.5 Pharynx

The pharynx is the part of the throat behind the mouth and nasal cavity and above the oesophagus and larynx.

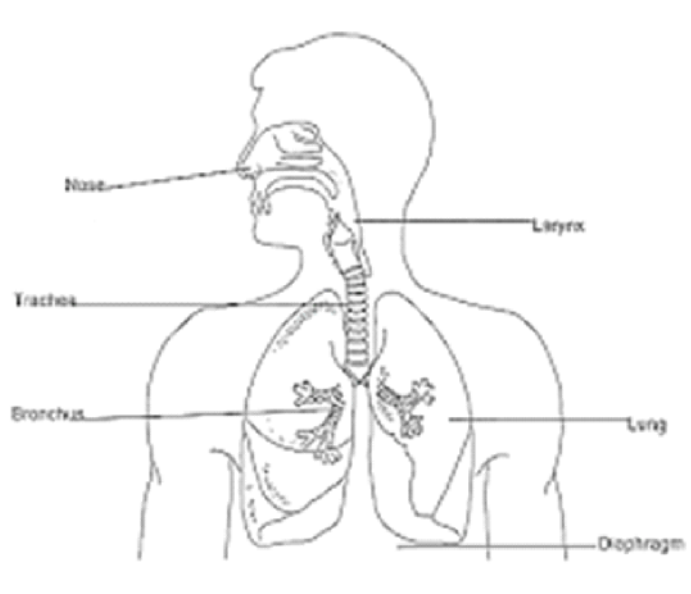
Pharynx has three part.

1. Nasopharynx
2. Oropharynx
3. Hypopharynx (laryngeal pharynx) from this point larynx starts.

4.5.1 Functions of pharynx

1. The pharynx is an organ involved in both the respiratory and digestive system.
2. It helps in warming and moistening the air.
3. Its oropharynx part consist of nerve endings which gives sensation of taste.

Location of the Pharynx



4.6 Larynx

The larynx commonly called the voice box, producing sound and involved in breathing. It lies in the midline of neck in front of oesophagus and it is about 2 inch long tube shaped organ.

4.6.1 Function of larynx

- The larynx provides a passage of air where air get moistened, filtered and warmed.
- We use the larynx when we breath, talk and swallow.
- Being a voice box vocal cord produce sound of varying loudness and pitches.
- During swallowing larynx moves upward which prevents food particles coming into the respiratory passage.

4.7 Trachea

The trachea is known as wind pipe which is continuation of larynx. It is 12 cm in length. It is present in front of oesophagus.

The lower part of trachea divides in left and right branchi, each going to the left and right lung.

4.7.1 Functions of Trachea

The primary function of the trachea is to transport air to and from the lungs.

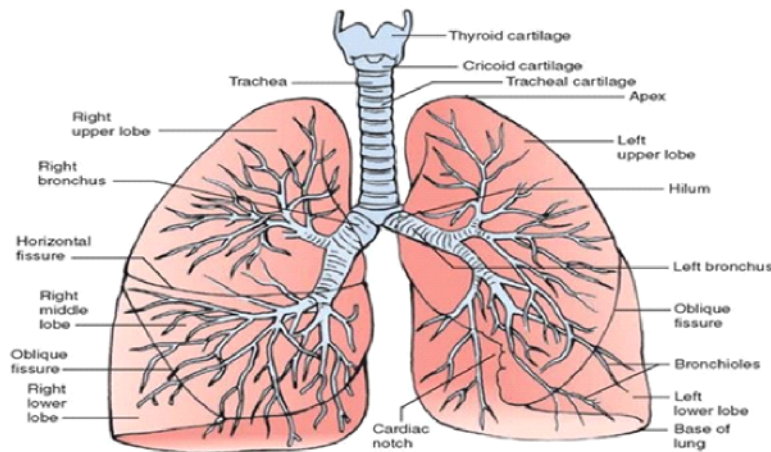
4.8 Lungs

These are paired cone shaped organs one on left and one on right side lying inside thoracic cage.

The right lung is broader, thicker and big as compared to left lung. The right lung is divided into three lobes while left into two lobes.

Lungs are vital organs for respiration protected in a bony cage. The outermost layer of lung is known as pleura.

Diagram of lungs



The lungs are a pair of spongy air filled organ. The trachea (windpipe) conducts inhaled air into the lungs through its tubular branches called branchi.

These branchi again divided into smaller branches called as branchioles. This network of branchi and branchioles are looks like a branch of tree.

At the end of bronchioles there are tiny sac like structure filled with air known as alveoli.

Alveoli is the site where exchange of (O_2 and CO_2) between blood and lungs takes place.

4.8.1 Function of Lungs

- Breathing process including inhalation and exhalation.
- Gaseous Chateaus exchange between lungs and blood stream and from blood stream to body tissues.

Note :-

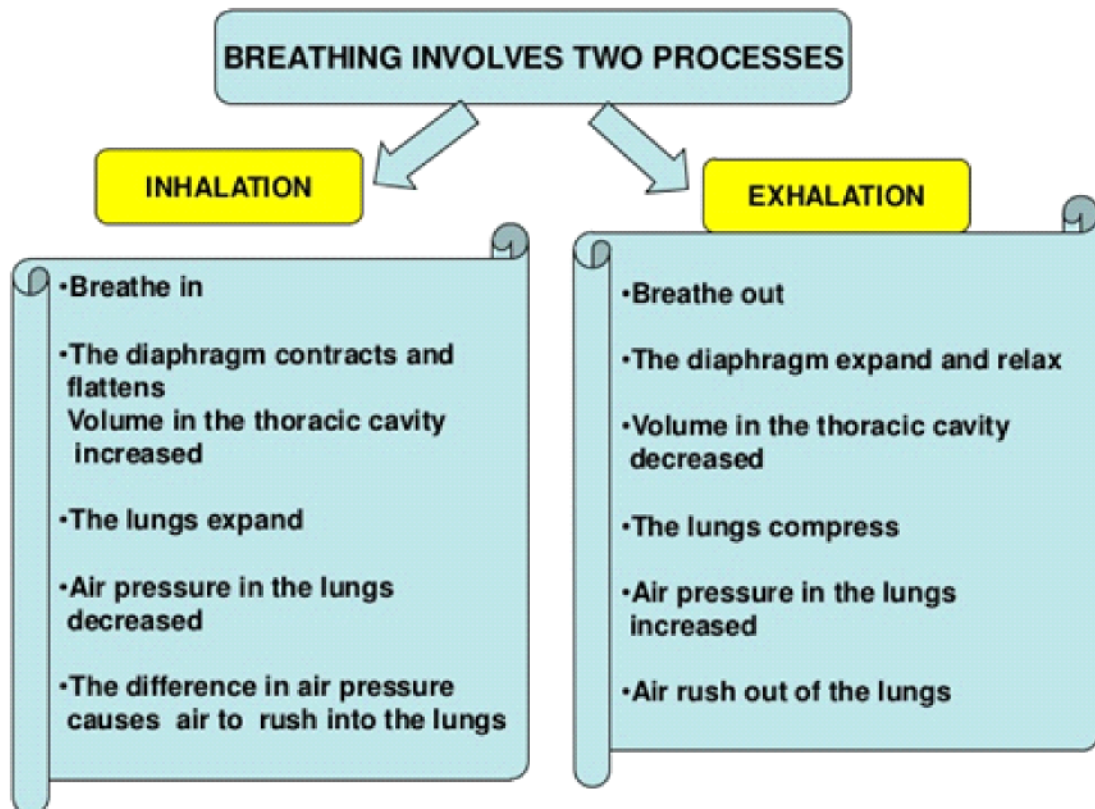
During fetal (body in uterus) life gaseous exchange (O_2 and CO_2) occurs through placenta. Lungs are filled with fluid with no breathing function. At the time of the birth with the first cry lungs get inflated with oxygen and breathing mechanism starts.

4.9 Mechanism of Respiration

The main purpose of respiration is to provide constant supply of oxygen to the cells of the body and removal of (CO_2) carbon dioxide from the cells. Normal breathing is a rhythmic process. The mechanism of respiration includes.

- **Inspiration (Breathing in)/ Inhalation :-** During inspiration the air passes and through nose, mouth trachea and into the lungs. From lungs finally it to flows to alveoli. This result in the expansion of thoracic cavity and upward movement of diagphragm. Through alveoli exchange of gases occurs and pure oxygenated blood is supplied to all cells of the body.

- **Expiration /Exhalation (Breathing out) :-** During this process diaphragm moves downward (relaxed) and it creates pressure inside the lungs. As a result of this lungs contract and air is focused out. During expiration again the gaseous exchange occurs and CO₂ and other waste product get expelled out.
- **Tidal volume :-** It is the amount of air which can be inspired and expired during normal breathing. The normal of is 500 ml.
- **Residual volume :-** It is amount of air remaining in the lung after the most powerful expiration. It is about 1200 to 1500 ml.
- **Vital Capacity :-** Total lung capacity is 5000 ml.



4.10 Summary

This system is a series of organs responsible for taking in oxygen and expelling carbon dioxide. The primary organs of respiratory system are two lungs which carry out gaseous exchange. By trapping dust and microbes in nasal cavity it protects against infection. It helps in sound production and sense of smell.

4.11 Glossary

- **OLFACTION** – The capacity of sense of smell
- **PATHOGENS** - Microorganisms like bacteria's viruses and fungi that causes infection and disease
- **INTRATHORACIC** - The region inside the rib cage between the top and bottom of lungs
- **DIAPHRAGM** - It is a thin muscle partition that separates abdomen from the chest

4.12 MCQs.

1. Production of sound is a function of
a) Larynx b) Pharynx c) nose d) Trachea
2. is involved in both respiratory and digestive system.
a) Alveoli b) Branchi c) Lungs d) Trachea
3. Normal lung capacity is
a) 1000 ml b) 2000 ml c) 3000 ml d) 5000 ml
4. Which lung has 3 lobes
a) Right lung b) Left lung c) Both d) None of them.
5. is known as wind pipe of human body.
a) Trachea b) Esophagus c) Bronchi d) Cresaphagus.

Ans :- 1) a 2) d 3) d 4) a 5) a

4.13 Reference Books

- 1) Human Anatomy & Physiology, For first year diploma in Pharmacy, Dr P.K. Puranik, By VBD publications Nagpur, Year 2003.
- 2) शरीरविद्यान परिचय, लीला ब. माडिवाले, अनंत प्रकाशन नागपूर, Third edition (2014).
- 3) शरीरशास्त्र व संलग्न आजार, अ. चिी. सफिया सिराज मोमिन, सिराजोशफि प्रकाशन कोल्हापूर, Fourth edition (2017).

4.14 Short Answer Question:-

1. Comparison between inspiration and expiration
2. Larynx
3. Nose

Long Answer Question :-

1. Explain in detail mechanism of respiration.
2. Explain in detail structure function of Lungs.

UNIT - 3

UNIT-3

Chapter - 5 The Digestive System

5.1 Preface

The human body is very complex as far as the structure and function is concerned. All the systems in the body are inter-related structurally and functionally. The foods we eat, the air we inhale keep us alive and functioning. It is worth noting that the food that we eat has to undergo a series of PROCESSING once we ingest it as it isn't directly useful for the body in the same form directly.

Digestion is the physiological process that transforms complex food that we eat into its simple form. The system that is involved in this digestive process is called as the digestive system and the organs that form the system are called as the digestive organs. The digestive system is also known as the Alimentary or Gastro-intestinal system. The digestive system provides nourishment to all the body cells from the external environment.

It must also be noted that the structure of the digestive tract that includes the organs are modified according to the type of diet. For example, in animals whose diet is mainly herbivorous or plant based the small intestines are longer (for digestion of fibers) as compared to the animals whose diet is carnivorous or animal based. The latter have a bigger stomach (for digestion of proteins) and a comparatively smaller length of the small intestine. Humans fall in the omnivorous type that is; humans have a mixed type of diet for which the stomach and small intestine are well modified.

5.2 Objectives

The objectives of the unit are

- To learn the structure i.e Anatomy of the digestive systems and the organs involved.
- To understand the functioning i.e. Physiology of the digestive system.
- To learn the digestive process as a whole, to understand the various juices that are secreted for the digestion to occur.

5.3 Digestive System in Detail

The digestive tract can be better divided structurally into the alimentary canal and the accessory organs involved in the digestive tract.

5.3.1 Alimentary Canal

The system includes the gastrointestinal tract or the alimentary canal which is about 11 meters in length. It is a hollow tube through which the food material passes and is processed along the way.

The alimentary canal consists of: mouth (Oral Cavity), throat (Pharynx), esophagus, stomach, Small Intestine, Long Intestine, colon, rectum, and anus.

- The compartments of the canal are separated by door like structures which are called as SPHINCTERS. It is the presence of these sphincters that food material remains in the compartment for some time of the process.
- The movement of the food from esophagus to anus occurs by a series of contractions and relaxations of the wall of the digestive path. This is called PERISTALSIS.

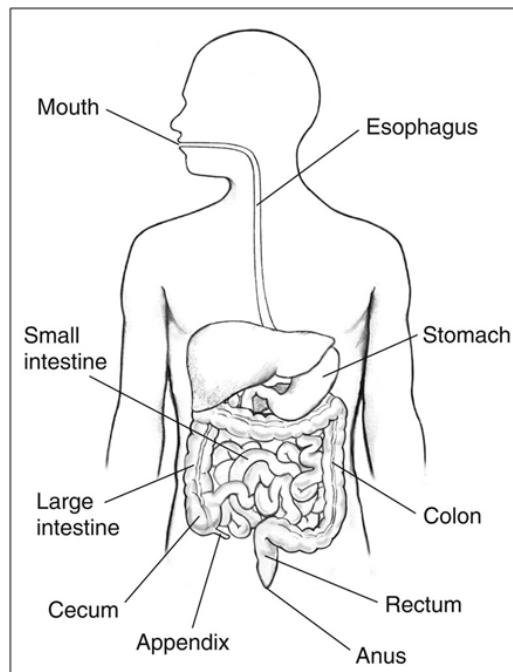


Figure No: 5.1 Digestive System
(Source : Book : Anatomy of human body)

The alimentary canal can be further divided into the following parts:

A) Mouth/oral cavity

The oral cavity consists of:

- Upper and lower lips
- Teeth (32) & Gums
- Tongue
- Hard and soft palate

The hard and the soft palate form the ceiling of the oral cavity. The tongue is a muscular organ, connected to the back part of the floor of the oral cavity. Taste buds are located on the upper surface of the tongue. The tongue helps in chewing, swallowing, speaking, tasting. The teeth are embedded in enamel (hardest substance in the body) & crush food into very small pieces and the salivary secretions from the salivary glands help these small pieces to be formed into a small, soft ball like structure also called as BOLUS.

B) Salivary Glands : There are 3 pairs of Salivary Glands, namely:-

- I. Parotid
- II. Sub mandibular
- III. Sublingual

They secrete saliva which is poured in the oral cavity through salivary ducts. The salivary glands secrete saliva which is watery in nature, it serves to moisten and cleanse the mouth, tongue, teeth & acts as a solvent in which solid particles can dissolve and enter the taste buds, thus giving the information of taste. The saliva also serves to begin the digestion process in the mouth itself as it acts on the food in the mouth.

C) Pharynx :

The pharynx is the continuation of the oral cavity. It is a muscular tube which leads to esophagus & trachea and ends into the stomach. It is a common path for food & air. Food from the oral cavity and air from nose enters the pharynx. The process up to here is voluntary. But from the pharynx downwards, it becomes involuntary.

5.3.2 Esophagus

Esophagus is a muscular tube about 25 cm (10 inch) in the chest, located just behind the trachea or windpipe. It is always in a collapsible form, it opens when food passes through it. The lower end of the esophagus joins the stomach. The food contents move across the esophagus by PERISTALSIS.

5.3.3 Stomach

The stomach is an important organ of the digestive tract. It can be explained as an expansible bag of food that is situated in the upper part of the abdominal cavity and just below the diaphragm. When empty, it is 'J' shaped, but after eating it bulges in all directions. The structure of the stomach contains the outer walls which are made up of crisscross muscles & the inner lining has glands that secrete GASTRIC JUICES (2-3Ltrs/day) which contain hydrochloric acid and some other chemicals. There is a thick coat of mucus inside. The stomach has a fundus, body, antrum and pylorus. The food comes in the stomach, stays there for 2 to 2½ hours, whereby it is digested by the gastric juices.

5.3.4 Small Intestine

The small intestine is a long tube about 3.5 meters (10 feet). Most of the digestion and absorption is completed in the Small Intestine. There are three parts of the small intestine:

- a) Duodenum
- b) Jejunum
- c) Ileum

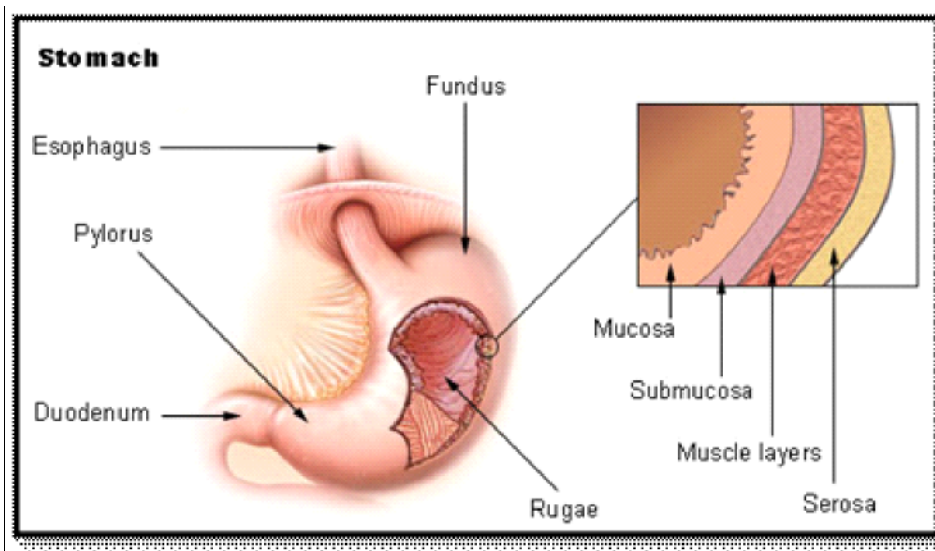


Figure No 5.2 : Anatomy of the Stomach
(Source :Internet)

The stomach opens into the 'C' shaped duodenum, which continues into the jejunum & further into ileum. The inner walls of the small intestine contain finger like projections called as 'VILLI' for absorption of digested food. These villi exist thousands in number along the inner walls. Thus the SI secretes about 1-2 liters of juice which contains water, mucus and sugar digesting and protein digesting enzymes.

5.3.5 Large Intestine

The Large Intestine is the terminal portion of the digestive canal. It is about 5 feet (1.5 meters) long and 2.5 inches in diameters. It occupies much part of the abdominal cavity. The 3 distinct parts of the LI also called as the COLON are

- Ascending colon
- Transverse colon
- Descending colon

There is no digestion of food in large intestine but there is significant absorption of water minerals and vitamins. Vitamins synthesized by the bacterial organisms present in the LI and absorbed in blood and are absorbed in the LI itself. The stools/ faeces are formed here. They remain for about 6-8 hours in LI. After further absorption of liquid the stools becomes soft then further are moved to the rectum.

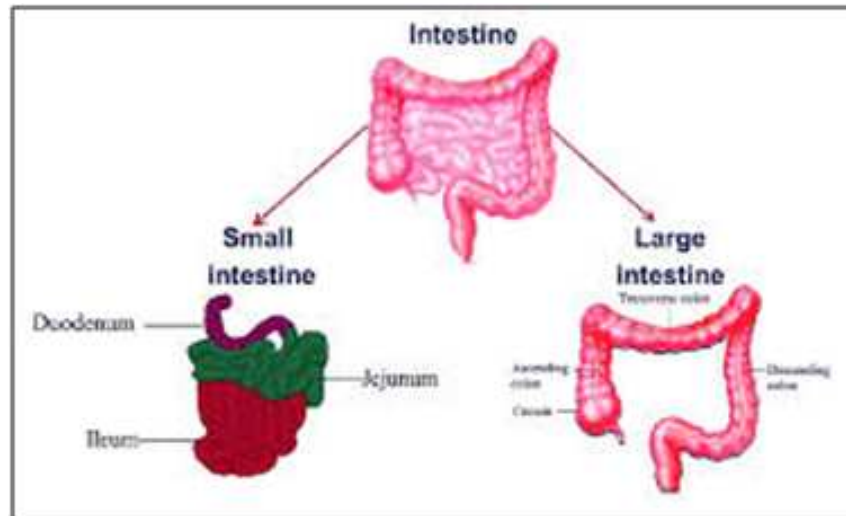


Figure No 5.3 : Anatomy of Large Intestine
(Source :Internet)

5.3.6 Rectum/Anal Canal

These are the final parts of the digestive tract that are mainly involved in the elimination of the waste faecal matter. The Large Intestine ends in the rectum that acts as a temporary storage for the faeces. (Faeces are the waste matter after food has been digested.) The anus is the opening at the end of the alimentary canal through which the faecal matter leaves the body. This process of excretion of faecal matter is called as defecation.

5.4 The Accessory Organs Involved

a) Liver

It is the largest gland in the body weighing about 1.5 kg situated in the right upper quadrant of the abdominal cavity. Many chemical processes that are a part of the body metabolism take place in the liver. Liver is a store house of GLYCOGEN and Vitamins A, B, D, E, K. Glycogen is better explained as the stored form of glucose or sugar that is the main component of Carbohydrates. Liver is an important centre for detoxification. It processes drugs, hormones, alcohol and other toxic substances. Bile which is a necessary juice for digestion to occur, is synthesized by the liver and stored in a special bag like structure called as Gall Bladder.

b) Pancreas

It lies behind and just below the stomach. It is an exocrine as well as endocrine gland. Exocrine glands are glands that require ducts for the release of their secretion; endocrine glands are ductless glands whose secretions are directly released in the blood. Exocrine part of pancreas secretes pancreatic juice which contains water, sodium bicarbonates, salts and various enzymes like amylase, trypsin, and lipase. Endocrine gland secretes hormones such as Insulin (secreted by beta cells) and Glucagon (secreted by alpha cells) that are essential for sugar metabolism.

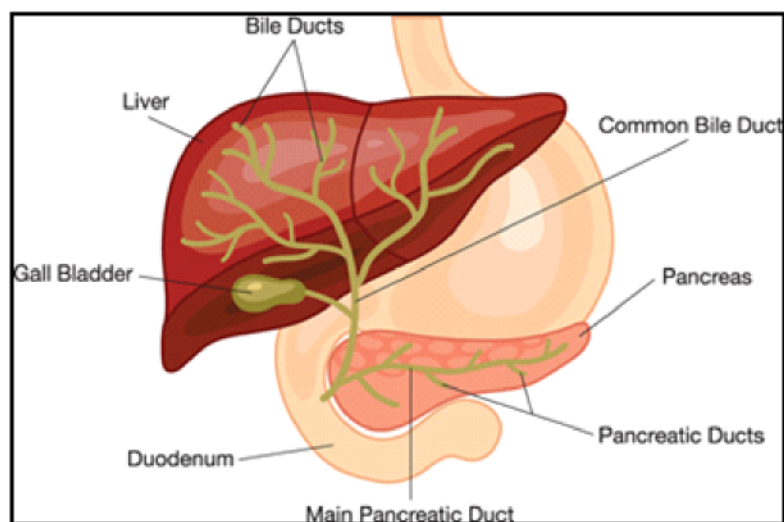


Figure No: 5.4 : Anatomy of Liver and Pancreas
(Source :Internet)

5.5 The Time Required For Digestion

The time required for the food that we eat to get fully digested depends on the quantity and combination of food. It also depends on the previous state of the digestive system.

We can grossly consider food as light, moderate and heavy .The time for digestion will be as follows:

Table No 5.1 - Time required for digestion and absorption

Food of Quality	Time for Digestion	Time for Absorption
Light	4-5 Hours	4-6 HOURS
MODERATE	5-8 Hours	6-8 HOURS
HEAVY	More than 8 hours	MORE THAN 8 HOURS

Table No 5.2 - Chemical aspect of digestive process

Constituent	Place of digestion	Involved Digestive Enzymes
CARBOHYDRATES (complex sugars to simple sugar)	Mouth, Stomach, Small Intestine	Saliva, Amylase, Sucrase, Lactase
PROTEINS (proteins to amino acids)	Stomach, Small Intestine	Pepsin, Trypsin, Peptidase
FAT (fat to fatty acids)	Small Intestine	Bile, Lipase

5.6 The Digestive Process As A Whole

1. Digestion of food in the mouth

- Mechanical digestion of breaking down food into smaller pieces begins in the mouth
- The teeth help in mastication and the tongue helps in moving the food in the oral cavity as well as the churning action. The saliva gets mixed with food and a bolus is formed which is ready to go to the stomach through the esophagus.
- The process of breakdown of carbohydrates into sugar predominantly begins in the mouth.

2. Digestion of Food In The Stomach

- Swallowed food enters the pharynx and then goes to the esophagus. Through esophagus comes in the stomach by the peristaltic action ;stays in the stomach for 2 to 2 ½ hours.
- In the stomach, the food is acted upon by the gastric juice and is further digested by the action of Pepsin and Hydrochloric acid and Mucus.

3. Digestion In The Small Intestine

- As the food moves downwards into the stomach the pyloric sphincter opens and the food is then propelled into the first part of the SI – Duodenum.
- Here it is acted upon by the Bile and Pancreatic juice and some intestinal enzymes. And it is still more digested to be in the form of micronutrients which are ready to get absorbed by the intestines to the blood.
- Food remains in the SI for 4 to 5 hours. Here it gets more digested and absorbed through the blood capillaries (thin blood vessels) in the intestinal wall which takes the micronutrients to the different parts of the body.

4. Digestion of Food In The Large Intestine

- Remaining undigested food goes ahead in the LI and stays here for 5-6 hours. In the colon, bacterial flora acts upon it.
- Excess water in the undigested food is absorbed and it gets a semisolid to solid form.
- This undigested food which is unwanted and sometimes contains toxic residues of food are all pushed into the Rectum and further more into the Anal canal.
- This process of eliminating the residual food is a part of the excretory system and is called as defecation.

5. Digestion and Central Nervous System

- A series of impulses are sent, from the brain to indicate the ‘feeling of hunger’ and thus we feel the need to eat food.
- As we begin eating and about 2/3rd of the stomach is filled, the receptors from the stomach send impulses to the brain and a centre of the brain gets activated and we get the ‘feeling of satiation’ also known as the feeling of fullness.
- The process of digestion after ingestion of food is autonomous and is continued till the food reaches the rectum.
- As the food reaches the anal canal a series of pressure changes arise and the voluntary action of defecation occurs.

5.7 Summary

Here is what we have learned from this unit.

1. The digestive system includes the digestive tract and accessory organs which combine and process food into their simple form that can be absorbed and utilized by the cells of the body.
2. The digestive system is a complex system that consists of various organs. Briefly, the alimentary canal that begins from the mouth, pharynx, esophagus, stomach, small intestine, large intestine, and ends in the rectum and anus. The associated accessory organs that are also essentially a part of the digestive tract are the salivary glands, liver, gall bladder and pancreas.
3. The digestive system requires a whole of about six to eight hours to reach the intestines and further defecation takes three to four hours.
4. The structures and functions of each of the organs of the digestive tract are different from one another, and these varied organs come together and carry out the digestive process harmoniously.

5. A series of various juices such as the pancreatic juice, gastric juice and enzymes such as trypsin, amylase, pepsin and various secretions from glands such as saliva are essential for the digestive process to occur.
6. A number of hormones such as insulin, glucagon are also needed to act upon, and carry out the digestion.

5.8 Glossary

1. **BOLUS** - A soft ball of food, typically found in the oral cavity by the action of saliva and chewing.
2. **PERISTALSIS** - A series of contraction and relaxation of the muscles of the esophageal wall, due to which there is movement of food from the upper end of the esophagus to the stomach.
3. **MASTICATION** - The action or process of food getting mechanically broken down into smaller fragments by the action of tongue, teeth and saliva.
4. **ENZYME** - Biological molecules (typically protein in nature) that speed up the rate of chemical reaction within the cells. They are vital for life and have wide range of functions. In the digestive tract, help in breaking down complex food into their simpler forms.
5. **SPHINCTERS**- The compartments of the alimentary canal are separated by door like structures which are called as sphincters.

5.9 Questions For Self Study

• TRUE OR FALSE

1. Vitamins and mineral do not get digested.
2. The Small Intestine is an important organ for digestion and absorption of food.
3. There exist thousands of villi in the intestine.
4. The bacteria present in the intestine synthesize vitamins.

Ans :- 1) True, 2) True, 3) False, 4) True

• MULTIPLE CHOICE QUESTIONS

1. Humans fall into which one of the following category of eaters.
a) Herbivores b) Carnivores c) Omnivores d) Scavengers
2. The hardest material in the body is
a) Enamel b) Calcium c) Iron d) Phosphorus
3. The small intestine has which one of the following parts
a) Two b) Three c) Four d) Five
4. Insulin is secreted by which cells of the pancreas
a) Alpha cells b) Beta cells c) Delta cells d) Gamma cells

Ans :- 1) c, 2) a, 3) b, 4) b

5.10 References

- i. Anatomy and Physiology: Yogic Context. By Dr. Sharadchandra Bhalekar, Kaivalyadhama Yoga Institute, Lonavla.
- ii. Yoga as a therapy –Medical view, Practical guide for health and diseases By Dr. Satish Pathak. Kaivalyadhama Yoga Institute, Lonavla
- iii. Essentials of Medical Physiology. By V.K. Sembhuligam, Prerna Sembulingam. Jaypee Brothers Medical Publishers (P)ltd. New Delhi.
- iv. Anatomy and Physiology of Yogic practices By M.M. Gore. New Age Books, New Delhi.
- v. Guyton and Hall Textbook Medical Physiology by John E Wall. Elsevier Pvt Ltd. India.

5.11 Write In Brief

- 1) What do you understand by digestion? Explain in detail how food is digested.
- 2) How is the structure of the human digestive tract, explain in detail.
- 3) How does the digestion in the Small Intestine take place? Explain in detail.
- 4) Write notes on 1. Liver 2. Pancreas 3. Stomach 4. Large Intestine.

Chapter - 6

Excretory System

6.1 Preface

We have learnt in the last chapter how the process of digestion takes place. How we derive energy from the food we eat is understood by us. But what happens to the left over contents from the digestive process? This is what we are going to learn in this chapter. Our body is continuously metabolizing various molecules. As a result of which various kinds of waste or toxic materials are produced in the body. These materials need to be eliminated timely for the body to be in a perfect health. The excretory system is a passive system in our body that removes excess and unnecessary materials so as to maintain the internal chemical homeostasis and prevent damage to the body.

6.2 Objectives

The objectives of this unit are:

1. To understand the excretory system in detail, the different organs involved in the system.
2. To understand the structure i.e. Anatomy and function i.e. Physiology of excretion.
3. To understand how urine is formed and excreted.

6.3 Excretory System In Detail

Our body has 4 main routes of excretion

- Kidneys (The Renal OR Urinary System)
- Lungs (The Respiratory System)
- Alimentary Canal (The digestive system)
- Skin

6.3.1. Urinary System

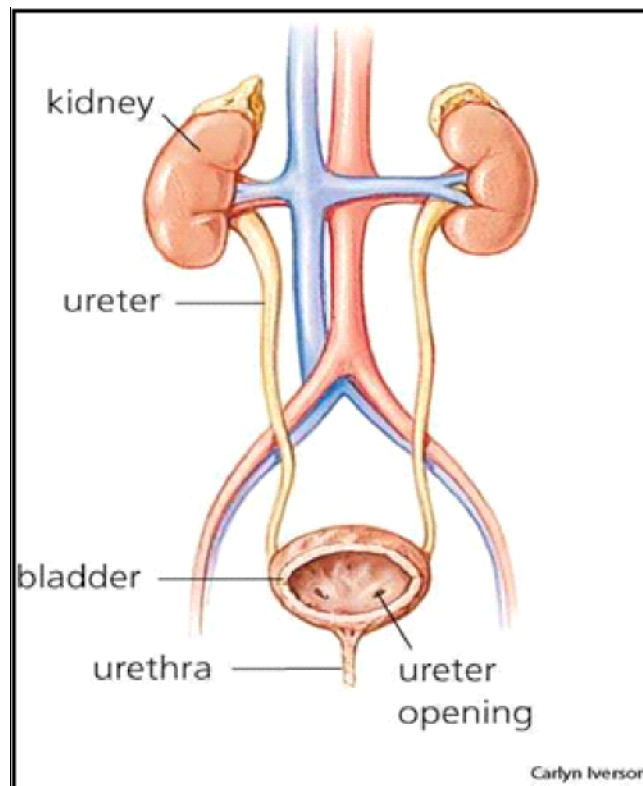


Figure No : 6.1 Anatomy of the Urinary System
(Source : Internet)

a) Kidneys

The kidneys are the main organ of excretion. Pair of kidneys control the water and other body fluids level. The Kidneys, ureters, bladder and urethra comprise to make the urinary structures. Each kidney is a reddish; bean shaped organ situated on the right and left sides against the posterior (back) abdominal wall.

The structure of the kidney when (seen in cut section) shows 2 visible parts. The outer part is the cortex and inner part is called as medulla. The medulla contains pyramids

(About 8-18 in number), these are internally made up of about 200,000 to 1.8 millions of Nephrons. The nephron is the functional unit of the kidneys.

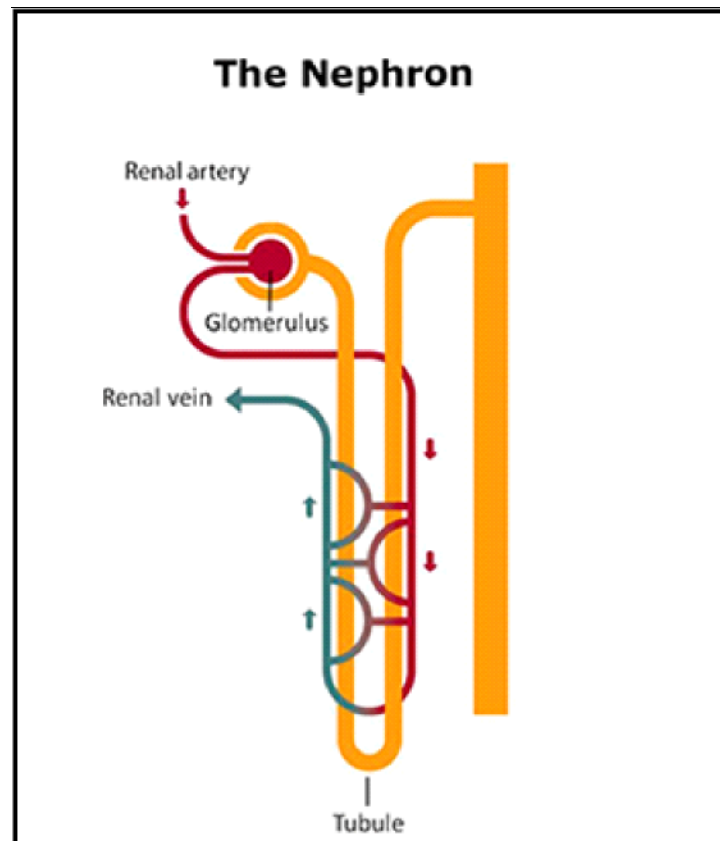


Figure No 6.2 Structure of Nephron
(Source :Internet)

Each nephron has further 2 parts namely – The Renal Corpuscle (where filtration takes place) and the Renal Tubule (where the filtered part moves and reabsorption takes place) The Renal corpuscles contains a network of capillaries and a cup shaped (Bowman's Capsule) structure through which the urine gets filtered. The Renal tubules are associated with small blood vessels where some of the water and electrolyte is reabsorbed and again returned to the blood. These tubules join to form the collecting duct many of these collecting ducts unite to form papillary duct. Many papillary ducts combine to form a minor calyx and these calyces unite to form into a major calyx. This opens into a single wide duct outside the kidney called as pelvis. Further the pelvis is extended as the ureter towards the bladder.

The main functions of the kidneys are as follows;

1. To maintain water balance in the body. If water intake is reduced kidneys increasing the water content by absorbing it or reducing the excess filtration of water. Depending on the intake of water and the external environment the concentration of the urine varies.
2. Help in excreting toxic substances by filtration.
3. Secrete Renin under the rennin-angiotensin-aldosterone mechanism which is an important hormone for maintenance of blood pressure and urine output.

4. Secrete erythropoietin which stimulates the production of red blood cells.
5. Kidneys also synthesize glucose from amino acids to regulate the blood glucose level. They also have a role in the vitamin D and Calcium metabolism.

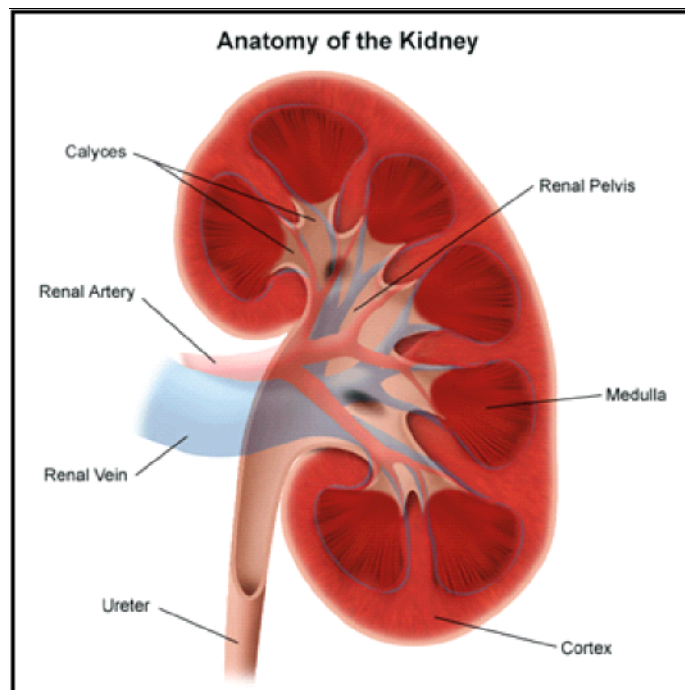


Figure No : 6.3 Anatomy of Kidney
(Source: Internet)

b) Ureter

Each kidney is connected to the urinary bladder by the URETER through which the urine is passed to the urinary bladder. Ureter is about 25-30 cm long with narrow diameters. The ureter starts from the pelvis and ends at the bladder. The walls of the ureter create a series of contractions so that the urine moves upwards to downwards.

c) Urinary Bladder

It is a hollow, distensible muscular organ, situated in the pelvic cavity. When it is empty it is in collapsed state. When it is filled with urine it becomes pear shaped and rises into abdominal cavity. The blood circulating through the kidney after getting filtered and separated from the other toxic substances & water products is sent back to the heart. Thus the urine formed is collected in the urinary bladder. The urinary bladder can store up to 700 to 800ml urine which is called as the capacity of the bladder.

Usually, when 200ml of urine is stored the natural urge of urination is stimulated. But the act of urination is partly controlled by ANS & partly voluntary. So even if the urge is created one can refuse the urge to some extent.

d) Urethra

Urethra is from the lower end of bladder, it throws the urine outside the urethral tube is 20 cm long in males and 6 cm long in females. At the junction of the urethra and bladder there exists a sphincter, because of which the junction is closed for some time to collect the urine and then during urination it is relaxed. The urethra has a layer of smooth muscles which help in contraction and relaxation of the urethra while the urine is passed.

e) Urine and Urine formation

Urine is the main excretory product formed as a result of the excretory process that goes on, in the urinary system. It is a clear, pale amber colored liquid with the average pH of 6.0 the presence of the

pigment urochrome. The color of the urine is due to it is slightly aromatic and when made to react with litmus it is slightly acidic in nature. On an average, around 1-2 liters of urine is excreted by man, but the quantities slightly vary depending up to the amount of fluids taken. It mainly contains water, urea and sodium chloride. Urea is the end products of protein metabolism. Around 30 gms per day urea is excreted, but this also depends on the protein intake and functioning of the liver in formation of urea.

When blood enters the kidney through the renal artery, the artery gets branched and rebranched till it reaches the nephron, where in the Bowman's capsule where water, minerals and other materials are filtered completely. At the Bowman's capsule the blood via the capillaries then leaves to join the renal vein and is redirected to the body. When further the filtered remainder reaches the renal tubule, much of the water and electrolytes are reabsorbed. Many tubules secrete waste, drugs and electrolytes into the fluid. This results in the formation of urine which is then collected at the pelvis and passed to the ureter. Through the ureter the urine enters the urinary bladder and then through the urethra finally it is excreted out of the body.

6.3.2 Excretion In The Respiratory System

The respiratory system also plays a small role in excretion as the process of respiration also produces certain products that are needed to be excreted.

The respiratory process at the cellular level produces carbon dioxide which is transported through the medium of surrounding tissue fluid to the blood. The blood is collected back into the capillaries and sent to the lungs for pulmonary circulation via heart. During inspiration or breathing in carbon dioxide is exchanged for oxygen and is eliminated during exhalation or breathing out.

The lungs also eliminate water vapour along with the air which is breathed out. Volatile substances like alcohol and anesthetic chemicals are eliminated in the form of vapour.

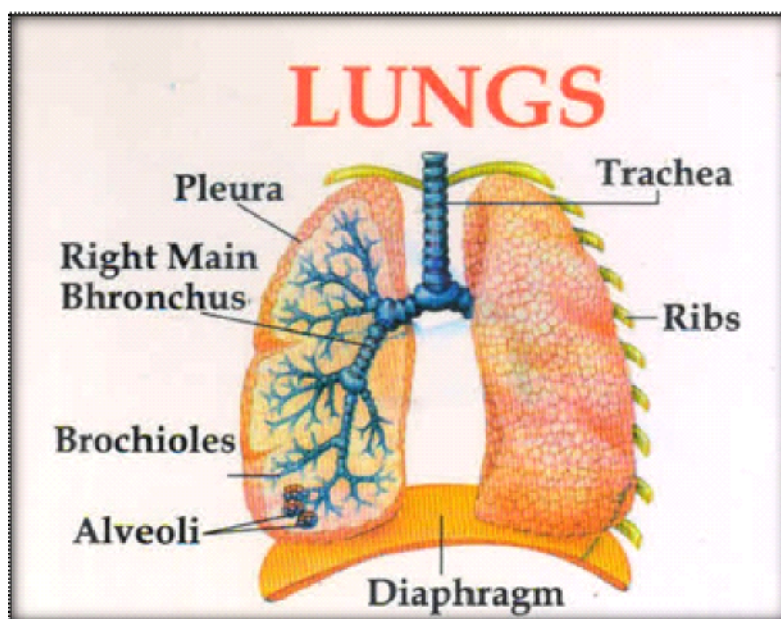


Figure No : 6.3 Structure of Lungs
(Source : Book , Anatomy of Human Body)

6.3.3 Excretion Through The Alimentary Canal

The digestive process that occurs in the alimentary canal finally reaches the rectum and anal canal. From here the excretion process begins and hence there is a need to include the alimentary canal in the excretory system. The feces which are the end, residual product of the digestion are generally semi-solid to solid in form. They contain a considerable quantity of bacteria, shed epithelium from intestine, a small quantity of nitrogenous matter, mainly mucin and some salts too. The other elements that exist in the feces are calcium phosphate, and a little iron, cellulose along with undigested food residue and water.

The act of eliminating the feces is called as defecation. It occurs when there is a rise in the pressure levels in the rectum as a result of which the feces are further pushed to the anal canal. Here under the control of external and internal sphincters, and contraction and relaxation of the anal muscles, the defecation occurs. The defecation is mostly voluntary but the central nervous system is involved for providing the impulses to the brain when these pressure changes occur in the rectum.

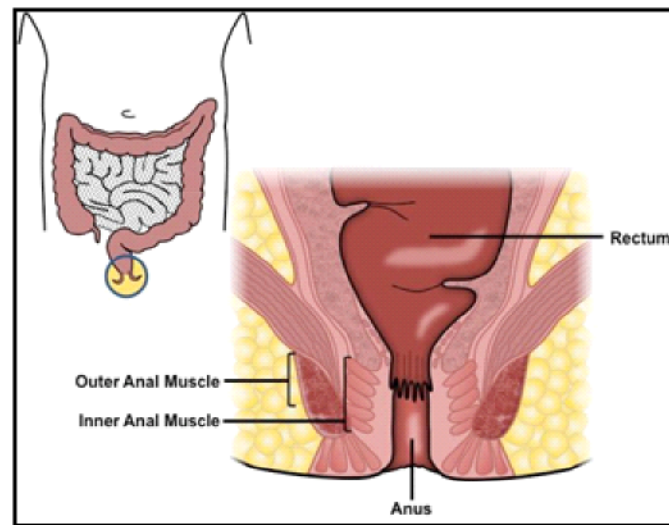


Figure No :6.3 Structure of Rectum and Anus (Source : Internet)

6.3.4 Excretion Through Skin

The skin is the largest organ covering the entire body is composed of several layers and glands. These several layer help in the excretion in smaller amounts which are essential for body functioning. Skin excretes water, salts and several organic compounds in the form of SWEAT. Degree of secretion of the sweat depends on the variation in the environmental as well as the body temperature. This because the heat is lost through sweating and the body is cooled.



**Figure No: 6.4 Layers of Skin
(Source :Internet)**

6.4 Summary

Here is what we have learnt from this chapter:-

1. The excretory system is the system that deals with the elimination of toxic and residual substances that are produced as a result of the body metabolism.
2. The excretory system is a multi organ system and also includes certain aspects of other systems.
3. The organs mainly involved in the excretory system are the kidneys, ureters, urinary bladder, urethra. Each of these organs work harmoniously and urine formation and excretion takes place.
4. The functioning unit of the kidneys is the nephron. It consists of the renal corpuscle and renal tubule along with the bowman's capsule. The blood filtration and formation of urine takes place in the nephron.
5. The average urine excreted in a day is around 1-2 litres depending upon the fluid intake and the external environment.
6. The excretion in the alimentary canal is through defecation of feces. Feces contain the undigested food and residual fibers left from the digestive process.
7. The respiratory process also eliminates carbon dioxide, water vapour and other volatile substances.
8. The skin also eliminates water and salts through the sweat, which is secreted by the glands present in the skin.

6.5 Glossary

1. **BOWMANS CAPSULE** : It is a cup shaped sack at the beginning of the tubular component of the nephron.
2. **UROCHROME** : Also called as urobilin, it is the chemical responsible for the color of the urine.
3. **RENIN**: It is the protein secreted by the kidneys which is responsible for maintaining the blood pressure and concentration of urine.

6.6 Questions For Self Study

• True or False

1. The neuron is the functioning unit of the kidneys.
2. A healthy person filtrates upto 100 liters of blood everyday.
3. Defecation is an involuntary process.
4. The urinary bladder stores urine that is formed and passed through the kidneys.
5. There are 8-18 pyramids in the renal medulla.

Ans :- 1) False, 2) True, 3) True, 4) True, 5) True

• Multiple Choice Questions

1. The most important function of excretory system is :
 - a) To provide energy to the body
 - b) To serve as building blocks of the body
 - c) To eliminate waste materials of the body
 - d) To act as defence mechanism
2. The number of nephrons in the kidney are:
 - a) 10 thousand to 20 thousand
 - b) 2 lakh to 5 lakh
 - c) 2 thousand to 5 thousand
 - d) 20 lakh to 1 million
3. Which of the following gives urine its characteristic color.
 - a) Urochrome
 - b) Glucose
 - c) Uric acid
 - d) Protein

Ans :- 1) c, 2) d, 3) a

6.7 Answer In Brief

1. Explain in detail about the excretory system.
2. Explain briefly how the excretory process takes place. Mention in detail the structure and function of the kidneys.

6.8 References

- i. Anatomy and Physiology: Yogic Context. By Dr. Sharadchandra Bhalekar, Kaivalyadhama Yoga Institute, Lonavla.
- ii. Yoga as a therapy –Medical view, Practical guide for health and diseases By Dr. Satish Pathak. Kaivalyadhama Yoga Institute, Lonavla
- iii. Essentials of Medical Physiology. By V.K. Sembhuligam, Prerna Sembulingam. Jaypee Brothers Medical Publishers (P) Ltd New Delhi.
- iv. Anatomy and Physiology of Yogic practices By M.M. Gore. New Age Books, New Delhi.
- v. Guyton and Hall Textbook Medical Physiology by John E Wall. Elsevier Pvt Ltd. India.

UNIT - 4

UNIT-4

Chapter - 7 Nervous System

7.1 Preface

The nervous system is very much highly developed and important system of human body. It controls almost all the activities of body. It includes brain spinal cord, networks of nerves (neurons).

Nervous system is classified into: - Central nervous system- CNS

Peripheral nervous system –PNS

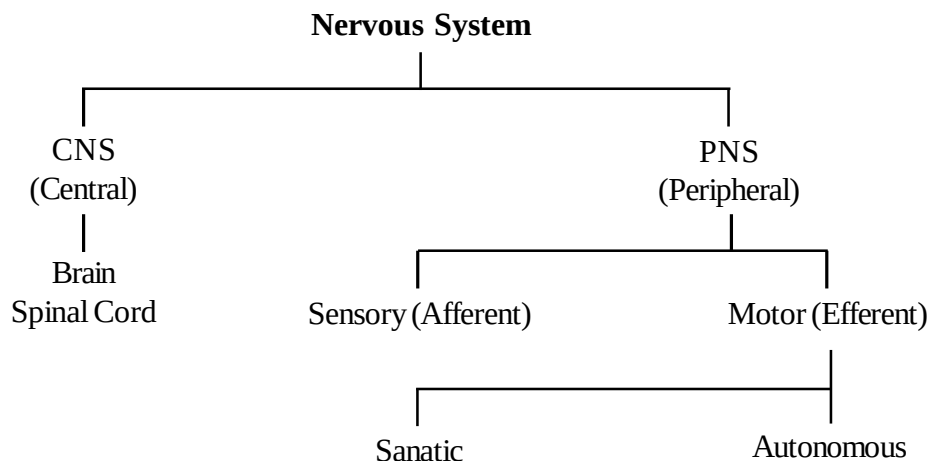
7.2 Objectives: -

Complete system of nervous system helps to understand.

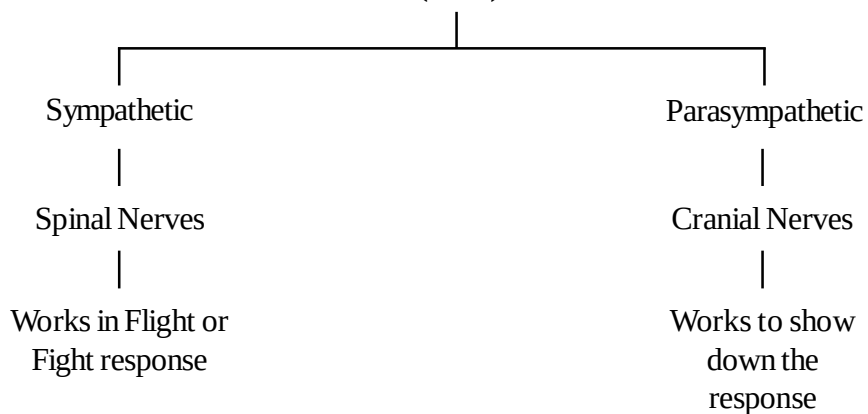
- Classification of nervous system
- Structure & function – Brain, Neuron, spinal Chord
- Mechanism of Reflex Action.

7.3 Classification of Nervous System

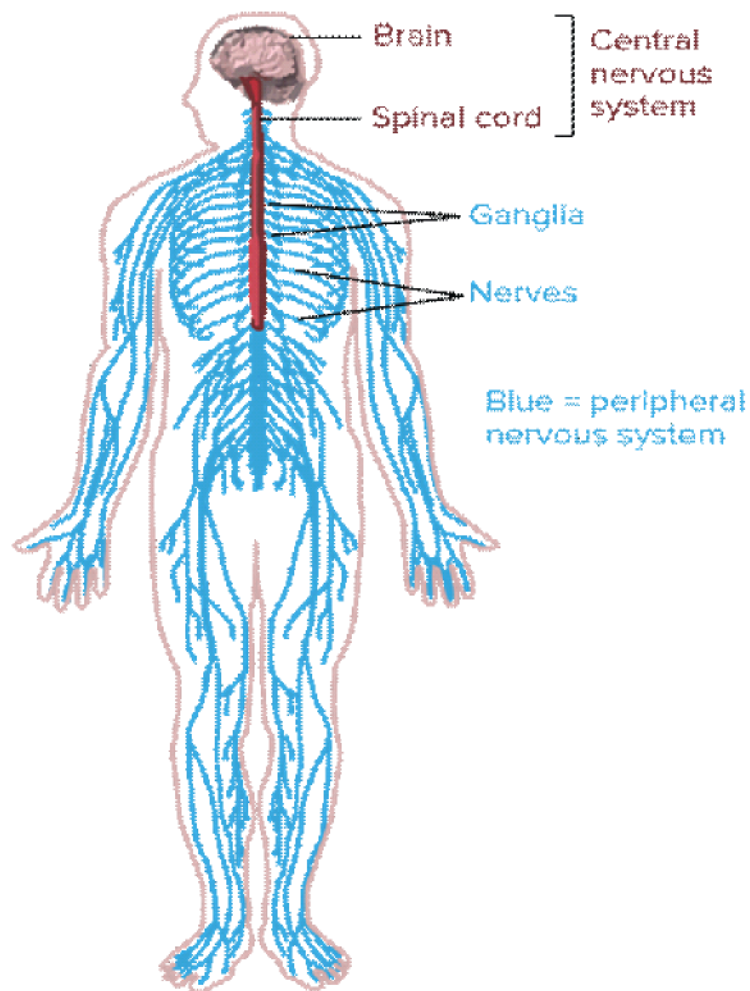
7.3.1. Nervous System



Autonomous Nervous System (ANS)



7.3.2 Diagram showing classification of Nervous system



7.4 Brain

The brain is the largest and most complex organ of human body.

It is situated inside the skull. The skull is hard bony covering, which give protection to the brain.

The average weight of brain is about 1000 gm to 1300 gm.

7.4.1 Cerebrum (Big Brain)

This is the largest part of brain and decided into right and left hemisphere. Cerebrum is covered (Protected) by three different layers. (meninges).

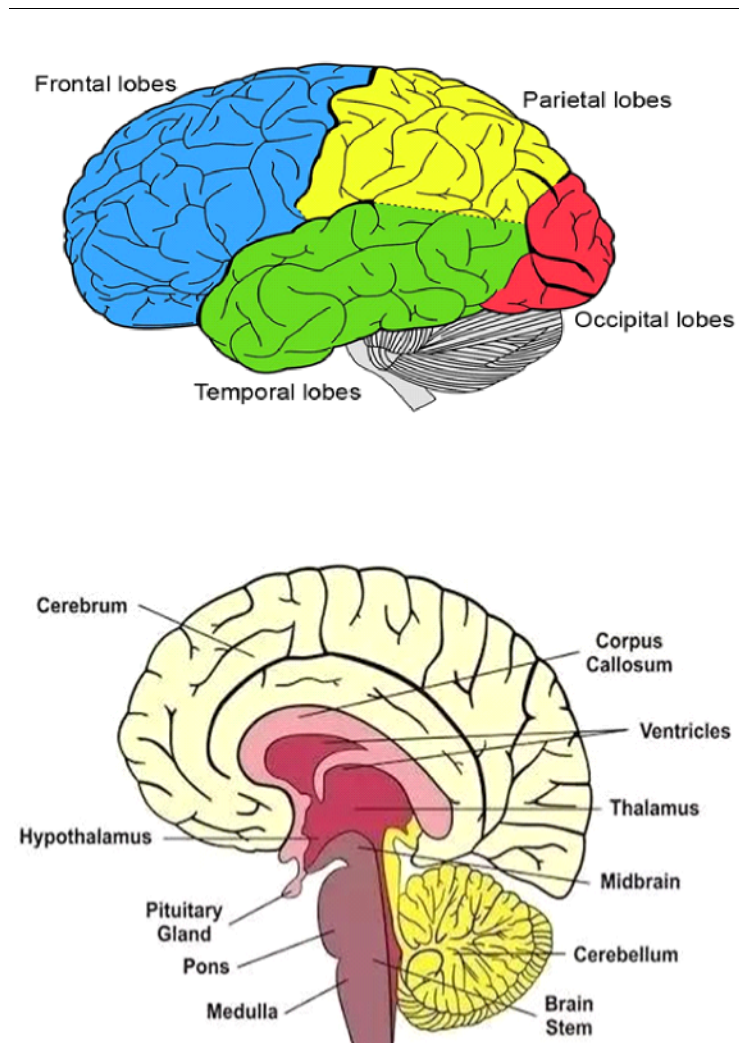
The Surface of cerebrum has outer thick layer which is made of nerve cell known as gray matter interior of cerebrum consist of fibers known as White matter.

The surface of the cerebrum is not plain but it has many folds known as sulci & Gyri. Cerebrum has different lobes

- Frontal lobe – Temporal lobes
- Parietal lobe – Occipital lobes

Which carries different functions.

Diagram of Cerebrum



7.4.2 Functions of Cerebrum

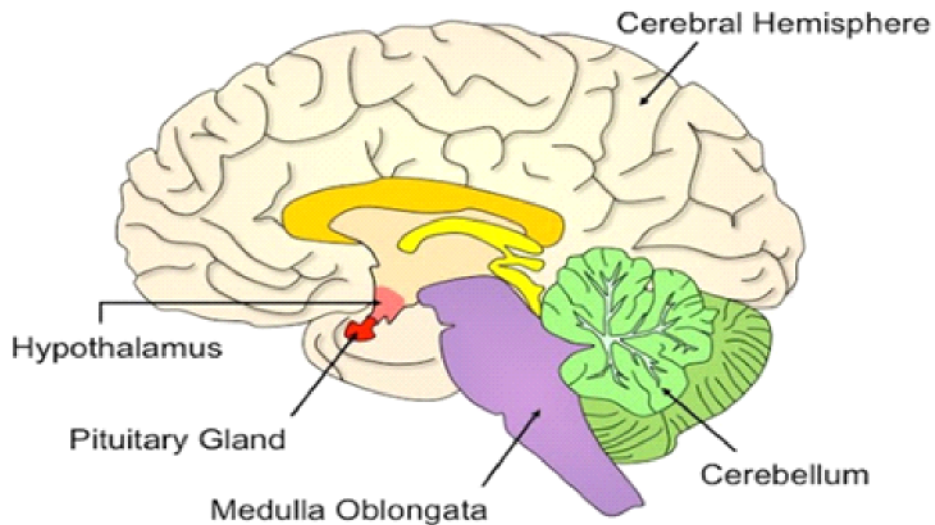
- This part of brain is responsible for higher mental function.
- Thinking
- Reasoning
- Memory
- Learning
- Producing & understanding language
- Planning & organisation
- Determining intelligence
- determining personality

7.5 Cerebellum

Cerebellum is a relatively a small portion of the brain-about 10 percent of the total weight, but it contains roughly half of the brain's neurons.

It is situated below the cerebrum behind the spinal chord. It is ovoid in shape. It has also two hemispheres.

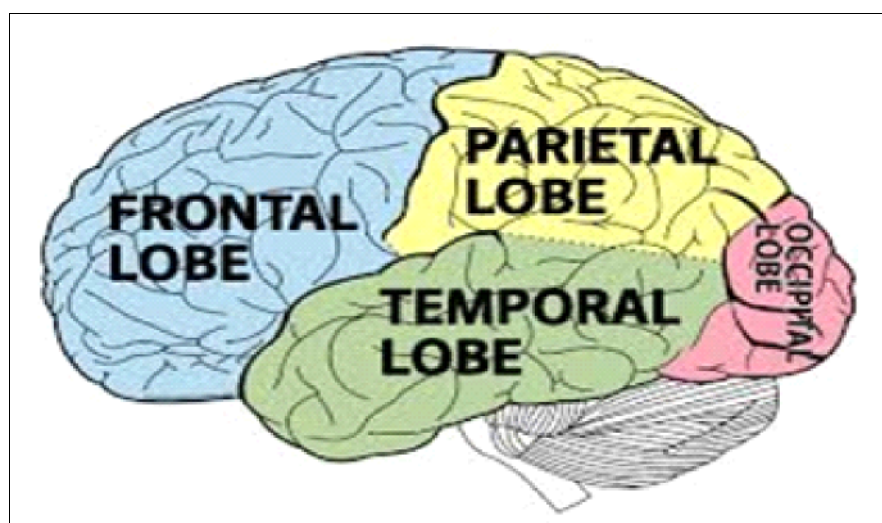
Diagram of cerebellum



7.5.1 Function of Cerebellum :-

1. Maintaining Body Balance.
 2. It controls the movements of various groups of muscles (Voluntary) ensuring smooth, even & precise action.
 3. Maintaining posture & helps in co- ordination of body movement.
 4. Learning motor behaviour.
 5. The skills that we learn by regular practice & it will remain throughout the life time for eg. Swimming, cycling, playing musical in front, walking, speech is Coordinated by Cerebellum.
 6. Vision - Cerebellum Coordinate Eye on movements.
- Other Functions
7. It has same rate in language, processing, mood, Emotional development by modulating sensations of anger of pleasure.

Diagram



7.6 Spinal Cord

- It is long cylindrical structure of nerves that starts from base of the brain.
- It is very vital structure so it is protected by bony vertebral Column.
- It is 45 cm long & it is part of central nervous system along with brain.
- It is surrounded protected layer of (meninges) & Cerebrospinal fluid. (CSF)

Function of spinal cord:

1. All signals are generated in the spinal cord and gets transmitted to different parts of nervous system and to the body.
2. It works as an important Communicator between the brain & all parts of the body.
3. Spinal cord is important centre of Reflex Action.

7.7 Neuron

Neurons are the basic functional cells of the nervous system. These are specialised cells generating electrical signals. (Action potential)

Due to these signals information transmits quickly from one part of body to another part.

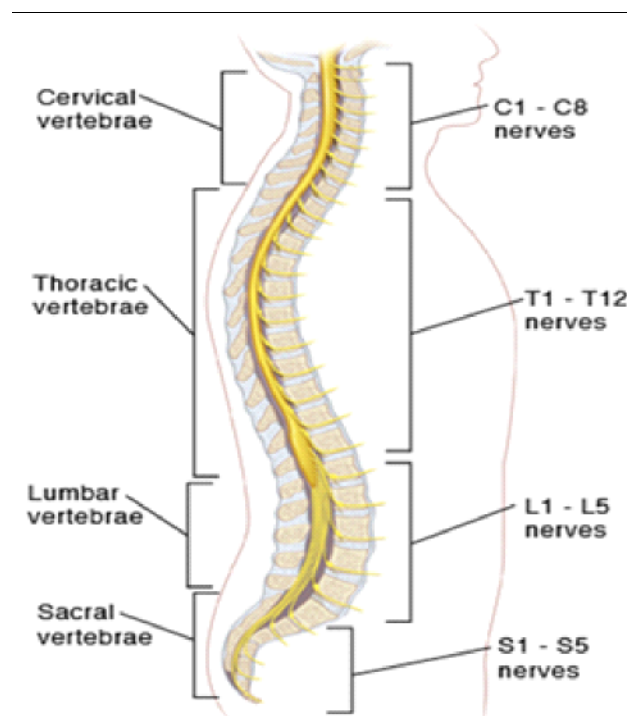
Formation of neurons occurs before birth (inside the uterus). Development of neurons occurs till 6th years of age.

If destruction of neuron occur it can't regenerate again.

7.7.1 Function of Neuron

- Receiving signal or information & thus helps in communication in brain & body parts.
- Neurons helps plays important role in reflex action.
- The gap between two neuron is called as synapse where secretion of neurotransmitter occurs.
- Neurotransmitter plays very important role in influencing emotions of person.

Spinal cord



7.8 Reflex Action

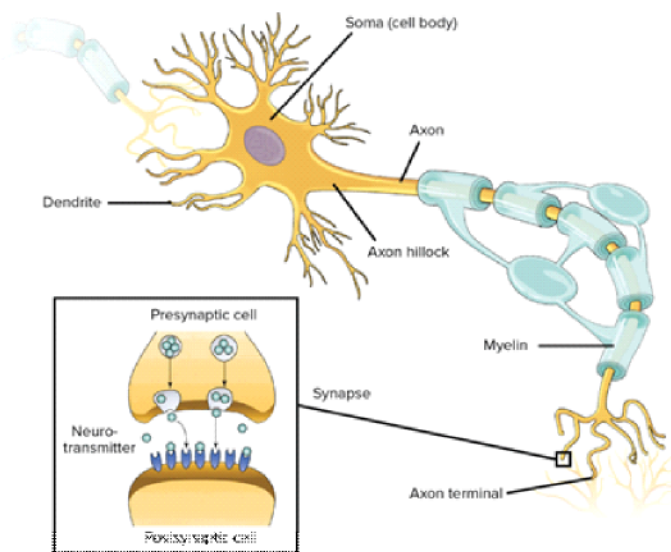
In reflex action spinal cord along with neuron is responsible for reflex movement.

Reflex arc is a path along which the nerve impulse travels from brain to muscle. (refer diag. Of reflex arc).

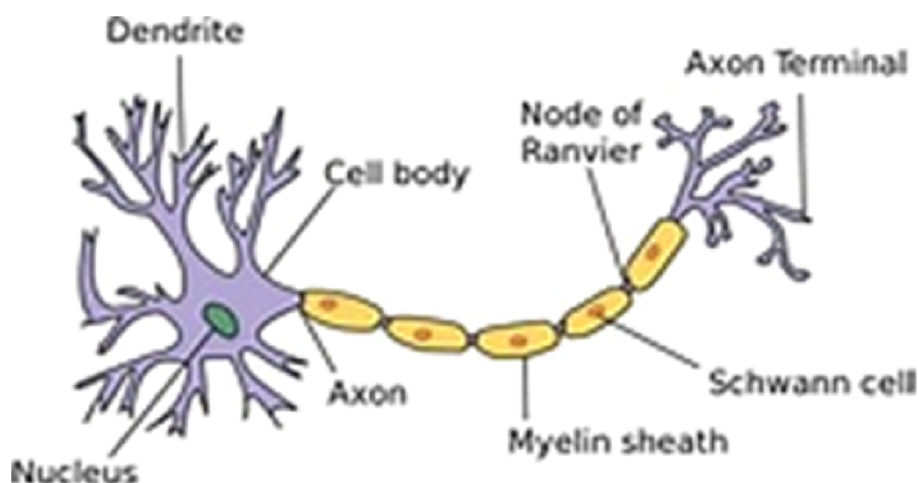
Few examples of reflex action are as follows.

1. The sudden removal of hand from a sharp object.
2. Effect of Light on pupil (Eye)
3. Coughing & sneezing because of irritant passage.
4. Sudden blinking when an insect comes very near to Eyes.
5. Sudden jerky withdrawal of hand or leg when pricked by a pin.
6. The diagram of reflex arc explain what happen if we accidentally touch something hot.

Diagram of Neuron



Neuron



7.9 Autonomous Nervous System (ANS)

ANS is an involuntary System means it cannot be controlled by humans.

ANS controls most of the visceral organs (internal organ) Like, lungs, heart, intestine, pancreas, liver etc. of human body.

It controls various mechanism of human body such as circulation digestion, respiration etc.

At the end of this Chapter. We will discuss difference between ANS and CNS (Central Nervous System)

ANS

1. Controls all involuntary activities of the body.
2. ANS Controls unconscious activities of body.
3. The activity is not under the Control of will hence name as ANS.
4. it regulates functions like gland secretion muscular movement, blood vessel movement.

CNS

1. It Controls all the voluntary activities of the body.
2. CNS Controls Conscious activities of the body.
3. The activities of CNS are under the control of will.
4. It regulates functions like movement of hand, legs, sitting etc.

7.10 Sympathetic and Parasympathetic nervous system

Sympathetic nervous system	Parasympathetic nervous system
1. Originates from thoracic and lumbar region of spinal cord.	1. Originates from cranial and sacral region of spinal cord.
2. It helps the individual to adjust the stress.	2. It takes part in building up the tissues.
3. It involves expenditure of energy.	3. It deals with conservation body energy.

7.11 Summary

Human nervous system helps us to understand that how several neurons are connected in a complex manner to carry out the smooth functioning of all organs of body. Nervous system along with brain helps in coordination of all body movements. It also focus on different parts of spinal cord which works in coordination with brain and helps in smooth body locomotion.

7.12 Glossary

- Spinal cord - long tube like structure which runs from base of skull and carries bundle of nerves to work in coordination with brain.
- Neuron - fundamental units of brain and nervous system which transmits information to other nerve cells, muscles, organs etc.
- Ganglia - A structure containing number of nerve cells with ovoid structures where one nerve enters and other exists.
- Reflex action - It is an involuntary unplanned sequence or action in response to a stimulus.

7.13 M.C.Q

1. The specialised Cells of nervous System are known as-
a) Neutrophil b) Neuron c) Basophil d) Red blood Cell
2. Thinking, reasoning, learning is a function of _____
a) Cerebrum b) Cerebellum c) Spinal Cord d) Neuron

3. Maintaining Balance & body posture_____
 - a) Cerebrum
 - b) Cerebellum
 - c) Hypothalamus
 - d) Spinal Cord
4. Spinal Cord lies inside a hard bony structure known as _____
 - a) Skull
 - b) Vertebral Column
 - c) Ribs
 - d) Pelvic Bones
5. Brain and Spinal Cord is a part of _____
 - a) ANS
 - b) CNS
 - c) SNS
 - d) PNS

Ans :- 1) b, 2) a, 3) b, 4) b 5) b

7.14 Reference Books

- 1) Human Anatomy & Physiology, For first year diploma in Pharmacy, Dr P.K. Puranik, By VBD publications Nagpur, Year 2003.
- 2) शरीरविद्यन परिचय, लीला ब. माडिवाले, अनंत प्रकाशन नागपूर, Third edition (2014).
- 3) शरीरशास्त्र व संलग्न आजार, जे. ची. सफिया सिराज मोमिन, सिराजोशफि प्रकाशन कोल्हापूर, Fourth edition (2017).

7.15 Short Answer Question :-

1. Reflex Mechanism
2. Cerebellum
3. Neuron
4. Types of Nervous system
5. ANS-Autonomous Nervous System

Long Answer Question –

1. Discuss in detail structure and functions of Cerebrum with a labelled diagram.
2. Discuss Spinal Cord in detail with labelled diagram.
3. Describe in detail classification of Nervous System.

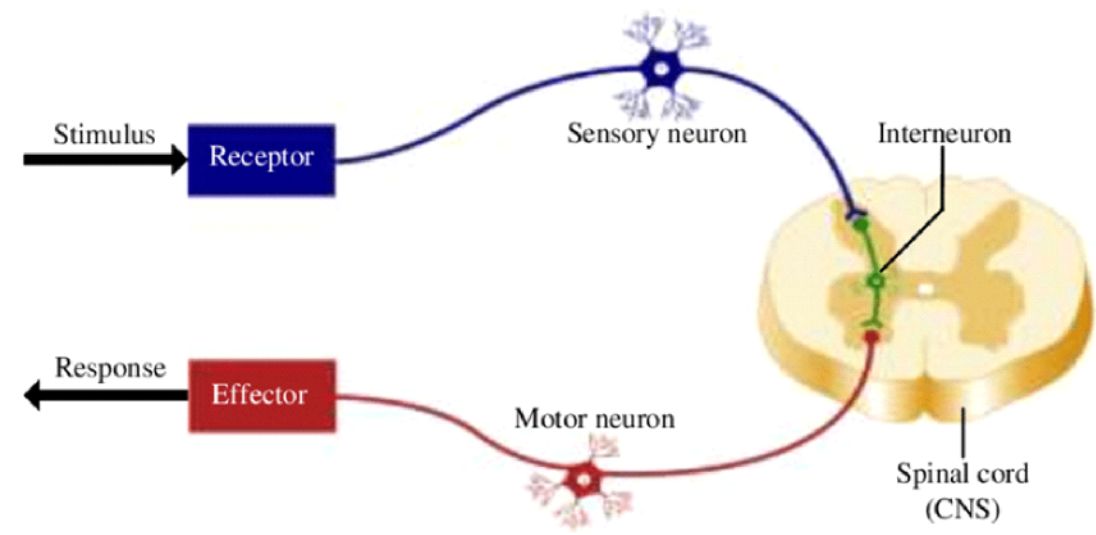


Figure 7.1 Reflex Arc

Chapter - 8

Endocrine System

8.1 Preface

Endocrine System controls various functions of the body. The glands of this system secrete chemical substances known as Hormones, which control many metabolic activities of the body.

This system deals with study of structure and function of various of endocrine glands. These glands have no ducts and hence also known as ductless gland. The hormones secreted by these glands directly mix into the blood and perform its function.

8.2 Objective

This system will focus on Definition and function of hormones

Structure and function of

- Pituitary gland
- Hypothalamus
- Thyroid gland
- Adrenal gland
- Pineal Body
- Pancreas

.. Mechanism of hormone action.

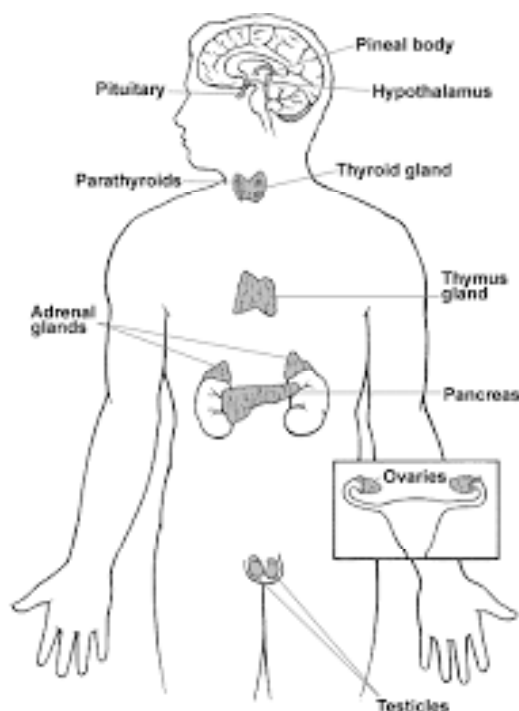
8.3 What are Endocrine glands?

Endocrine glands are ductless glands. These glands secrete their product (hormones) into the blood.

8.3.1 Definition of Hormone

Hormones are the chemical substances which are formed in Endocrine gland and carried by the blood to the target organ or tissue.

Endocrine system



8.3.2 Names of Various Endocrine gland

Sr. No.	Name	Location
1	Pituitary gland	Base of the brain
2	Thyroid gland	In the neck in front of trachea
3	Adrenal glands (2 in no.)	On the top of Each Kidney
4	Pancreas	Abdomen
5	Ovaries in female (2 in no.)	On each side of uterus
6	Testes in male (2 in no.)	In scrotum
7	Pineal Body	Brain

8.3.3. Functions of Endocrine System

Endocrine system controls the following process

1. Growth and development of the body
2. Homeostasis of - means "Internal balance of the Body System".
3. Metabolism - "Through which Energy is created inside the body".
4. Reproduction
5. Response to stimuli.....(Stress, injury)
6. Thermal Regulation maintaing Body temperature.

8.4 Pituitary Gland

Pituitary gland regulates and controls maximum activity of the body so pituitary gland is known as master gland of Endocrine system.

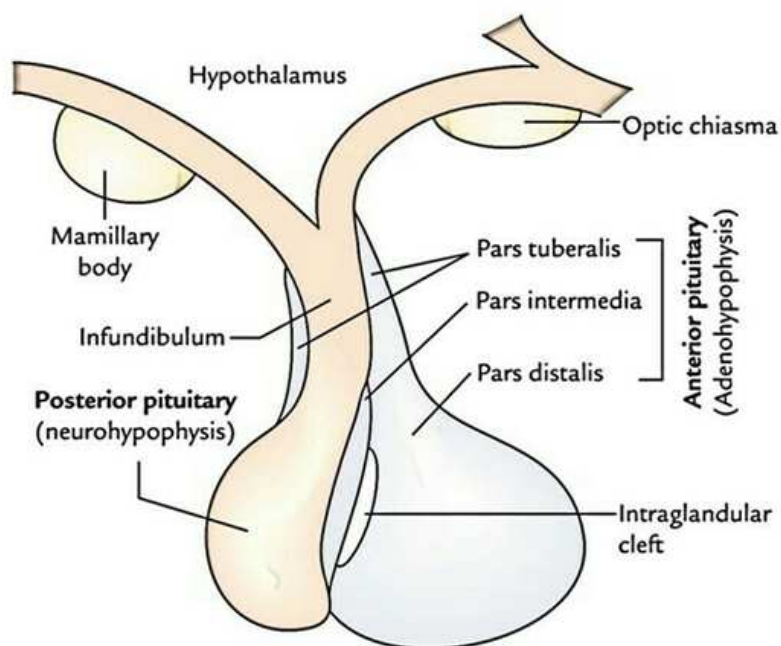
It is situated at the base of the brain below the hypothalamus and it is attached to it by the stalk (infundibulum)

It is a size of pea shaped. Pituitary gland structurally divided into two parts.

1. Anterior lobe
2. Posterior lobe.

Both the lobes secretes various hormone.

Diagram of pituitary Gland.



8.4.1 Functions of Pituitary Gland

1. It controls the growth and activity of thyroid glands and stimulate its secretions.
2. Stimulate adrenal gland to produce their hormones.
3. Hormones of pituitary gland helps in the formation of ovum and sperm by stimulating ovaries and testies.
4. Pituitary gland direct effects on mammary gland (breast) to secrete the milk.
5. It promotes contraction of uterine muscles during child Birth.
6. In female it produce oestrogen and progesterone and in male produce testosterone.

8.4.2 Harmonces of pituitary Gland

Sr. no.	Anterior lobe	Sr. no.	Posterior lobe
1	Growth Hormone (GH)	1	Oxytocin
2	Thyroid stimulating Hormone . (TSH)	2	Vasopressin
3	Adreno corticotrophic hormone.(ACTH)		
4	Prolactine		
5	Melanocyte stimulating Hormone (MSH)		
6	Gonadotrophic hormones		
	- Follicle Stimulating Hormone (FSH)		
	- Leutinizing Hormone (LH)		

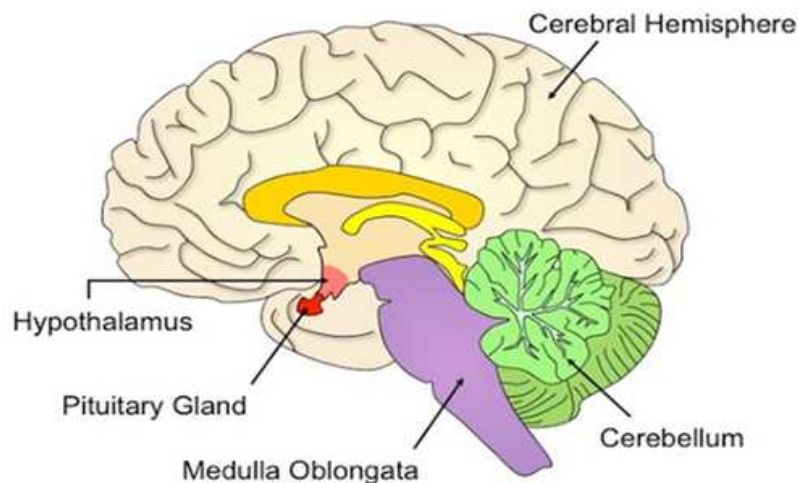
8.5 Hypothalamus

Hypothalamus made up of group of nerve cell. It is located above the pituitary.

Hypothalamus is a part of brain but works in coordination with pituitary glands and controls various activites of the body.

There is a very important axis in our body known as hypothalamo-pitutory which helps in smooth coordination of all the endocrine glands.

Hypothalamus



8.5.1 Functions of Hypothalamus

Hypothalamus controls mechanism of

- Hunger
- Thirst
- Urinary bladder contraction
- Heart rate.

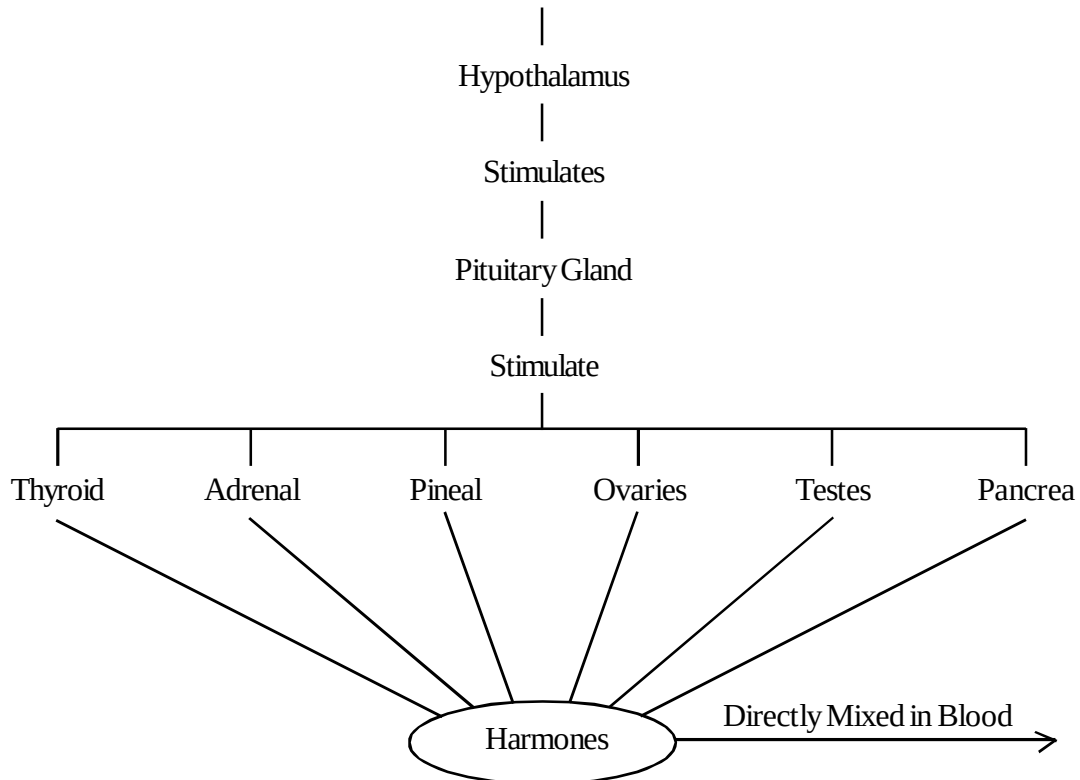
It acts as a main communicator between nervous and endocrine system.

Regulating of body temperature.

It is the main centre for

- Emotions
- Regulating sleep pattern.

Mechanism of Hypothalamo-Pituitary axis

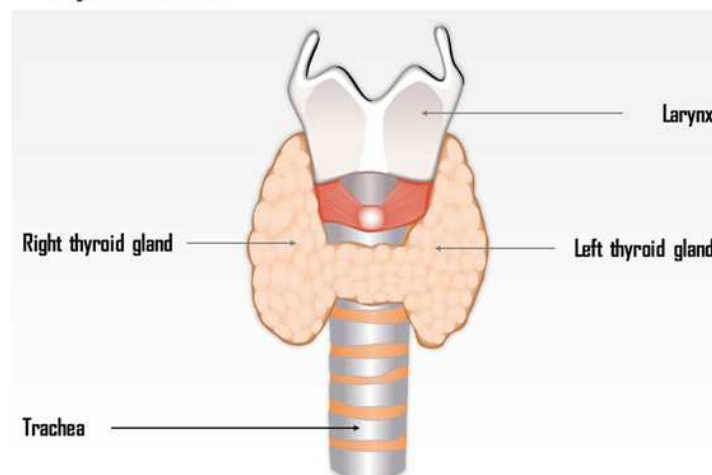


8.6 Thyroid Gland

This endocrine gland is situated in the neck in front of trachea. This is a highly vascular gland. It consists of two lobes roughly cone shaped.

It is butterfly shaped. It is brownish red in color, rich in blood vessels. Two lobes are joined together.

Thyroid Gland



8.6.1 Hormones of Thyroid Gland

It secretes two hormones.

1. Thyroxine (T₄)
2. Triiodothyronine (T₃)

Iodine is essential for formation of thyroid hormones.

1.6.2 Functions of Thyroid Gland

1. Regulation of metabolism by regulating all metabolic activities energy is produced required for body activities.
2. Regulates growth and development specially in infants and foetus.
3. Regulation of activity of nervous system. Thyroid hormones are important for normal activity of central nervous system (CNS) and its deficiency causes mental retardation.

1.7 Pancreas

This endocrine gland is situated in upper abdomen. It is surrounded by spleen, liver, small intestine.

It is about six (6) inch long. This gland has two functions.

- Exocrine function (Digestive function).
 - Endocrine function (Hormone Secretion)
- .. Exocrine functions include the secretion of pancreatic juice for digestion of food.
- .. Endocrine pancreatic Hormones:

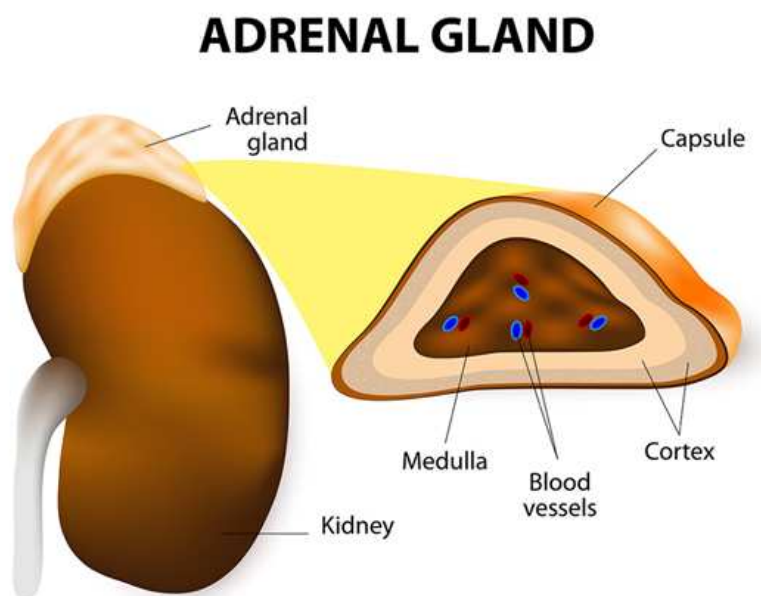
1. Insulin
2. Glucagon

Important function of pancreatic hormone is to regulate the blood sugar level in the body.

8.8 Adrenal Glands

There are two adrenal glands situated at the top of the kidneys. It has two layers. Triangular in shape.

1. Outer - Cortex
2. Inner - Medulla



8.8.1 Hormones Secreted by adrenal gland

Sr. No.	Adrenal Cortex	Sr. No.	Adrenal Medulla
1	Cortisol	1	Adrenaline
2	Aldosterone	2	Noradrenaline
3	Androgen		

8.8.2 Functions of Adrenal Gland

1. One of the most important function of Adrenal gland is the “Fight -or -Flight” response. When the person is stressed or in danger, adrenal gland release hormones which provides energy for vital functions of the body (e.g. Breathing, Heart rate etc.)
2. Androgen hormone helps in development of Genital organs of male and female.
3. Aldosterone helps in maintaining water balance of the body.
4. Adrenal glands maintains the blood pressure.

8.9 Pineal Gland

Pineal gland is a small pea shaped gland deeply situated in the brain. (Centre of the brain) It is also called as Third Eye for many reasons including its location deep in the centre of the brain and its connection to the light.

Spiritual tradition suggest that it serves as a metaphysical connection between physical and spiritual world.

Functions of pineal -

1. It is associated with the development of genital organ by release of gonadotrophic hormones.
2. It also regulates hormone melatonin. Which plays important role in regulating normal sleep patterns.

8.10 Summary

This unit helps us to get information about endocrine system which is a series of glands that produces and secretes hormones which the body uses for wide range of functioning such as respiration metabolism reproduction growth and development. Pituitary gland and hypothalamus works in coordination and sends message to other endocrine glands of body.

8.11 Glossary

- Hormone - A chemical substance which is released by endocrine glands directly into blood to carry out body functions.
- Homeostasis - The tendency to maintain a stable, relatively constant internal body environment
- Metabolism - It is a process by which your body converts what you eat and drink into energy. It is a complex process where all food and beverages combined with oxygen to release the energy that your body needs

8.12 MCQs.

1. gland is known as master endocrine gland.
a. Pineal gland b. Pituitary gland c. Thyroid gland d. Adrenal gland
2. Insuline is secreted by.....
a. Hypothalamus b. Pancreas c. Pituitary d. Adrenal
3. is essential for development of thyroid hormones.
a. Iodine b. Insuline c. Cortisol d. Adrenaline.
4. Cortisol is a hormone secreted by
a. Pineal body b. Hypothalamus c. Adrenal gland d. Thyroid gland

5. hormone produces contraction of uterine muscle during childhood.

- a. FSH b. LH c. Growth hormone d. Oxytocin.

Ans :- 1) b, 2) b, 3) a, 4) c 5) d

8.13 Reference Book

- 1) Human Anatomy & Physiology, For first year diploma in Pharmacy, Dr P.K. Puranik, By VBD publications Nagpur, Year 2003.
- 2) शरीरविद्यान परिचय, लीला ब. माडिवाले, अनंत प्रकाशन नागपूर, Third edition (2014).
- 3) शरीरशास्त्र व संलग्न आजार, जे. सी. सफिया सिराज मोमिन, सिराजोशफि प्रकाशन कोल्हापूर, Fourth edition (2017).

8.14 Short Answer Question

1. Pineal Gland
2. Hypothalamo pituitary Axis
3. Thyroid gland

Long Answer Question

1. What is endocrine System and discuss in detail pituitary gland.
2. Discuss in detail structure and function any three Endocrine glands.